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STRUCTURE AND RELATIONS OF MYLOSTOMA.

By C. R. Eastman.

With Five Plates.

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No. 1. — *Structure and Relations of Mylostoma.* By C. R. Eastman.

It is proposed in the present communication to point out the intimate structural resemblance between Mylostoma and Dinichthys, and, taking these forms as typical examples of Arthrodires, to compare their general organization with that of Neoceratodus and other Dipnoan fishes. Evidence is presented for associating Arthrodires with Dipneusti, and their relations to fossil and recent members of the subclass are considered. A summary is also given of the leading facts in the evolutionary history of Dipnoans since their first appearance in the Lower Devonian until their decadence bordering upon extinction in the modern fauna.

One of the chief contentions of the present paper is that which relates to the systematic position of Arthrodires; and as scarcely any two modern writers are agreed upon this matter, it is instructive to review the more prevalent theories concerning the relations of these extinct forms to other fishes. The "family Placodermi" of M'Coy was instituted in 1848 for the reception of Coccosteus, Pterichthys, and Asterolepis, and for more than forty years these genera and their allies were considered to form a natural group of Ganoidei. Elevated by subsequent writers to ordinal and even higher rank, it remained for Cope, in 1889, to recognize the heterogeneous nature of this assemblage, and to initiate its disruption. He first proposed the removal of Asterolepis from the class of Pisces altogether, and at the same time referred Coccosteans provisionally to the Crossopterygii. (Amer. Nat., 1889, **32**, p. 856). Shortly afterwards, however, following Smith Woodward's suggestion, the several families of Coccosteus-like fishes were grouped, under Woodward's new term of Arthrodira, in a separate order of Dipnoans.[1] This arrangement obviously implied, though it had not as yet been demonstrated, that the Arthrodiran skull was truly autostylic, and that a secondary upper jaw was not developed. One of the chief reasons which influenced the novel association of Arthro-

[1] Cope, E. D. Syllabus of lectures on geology and paleontology. Philadelphia, 1891, p. 14.

dires with Dipnoans was the parallelism, previously noted by Newberry,[1] between the dentition of Dinichthys and that of Protopterus. The absence of any indication of a hyomandibular bone, even in the most admirably preserved skeletons, and of more than a single ossification in the mandibular ramus, were considered sufficient reasons for excluding Arthrodires from Teleostomes.

This provisional classification of Arthrodires with Dipnoans met with an indifferent reception on the part of most paleontologists, and was afterwards rejected by some of its early supporters, notably Traquair and Bashford Dean. Smith Woodward himself conceded, in 1898, that "the systematic position of this extinct order [Arthrodira] is indeed doubtful."[2] Traquair's defection dates from 1900, when he declared, in his Bradford address, in favor of considering Arthrodires as "Teleostomi belonging to the next higher order, Actinopterygii."[3] The following year Dean expressed the radical view that they were not fishes at all, but representatives of a distinct class, named by him Arthrognathi, and conceived to have possible kinship with Ostracophori.[4] It was even allowed that subsequent researches might demonstrate a union between Ostracophores and Arthrognaths, whereby M'Coy's group of Placodermata would be restored. This was a complete reversal of his former view that the "jaws, specialized dentition, fin-spines, and highly evolved pelvic fins at once separate this group from the lowly Ostracoderms."[5]

By far the most comprehensive definition of the term Placodermata is that of Jaekel, in 1902, whereby the Pteraspids, Tremataspids, Psammosteids, Cephalaspids, Asterolepids, and Coccosteans were all embraced within a single group.[6] This assemblage was modified a twelvemonth later, however, in that the two last-named divisions were bracketed together under the new division of "Temnauchenia," in contradistinction from the so-called "Holauchenia," — a collective designation applied to Pteraspids, Tremataspids, Cephalaspids, Drepanaspids, and

[1] Newberry, J. S. Descriptions of fossil fishes. Rept. Geol. Surv. Ohio. Paleont., 1875, **2**, p. 5.

[2] Woodward, A. S. Outlines of vertebrate paleontology. Cambridge, 1898, p. 64.

[3] Traquair, R. H. Vice-Presidential address. Rept. Brit. Assoc. Adv. Sci. Bradford meeting, 1900, p. 779.

[4] Dean, B. Palaeontological notes. Mem. N. Y. Acad. Sci., 1901, **2**, p. 113.

[5] Dean, B. Fishes, living and fossil. New York, 1895, p. 130.

[6] Jaekel, O. Ueber Coccosteus und die Beurtheilung der Placodermen. Sitz. Gesell. Nat. Freunde, Berlin, 1902, p. 103.

the Birkeniidae. All of these forms, or if the expression be permitted, Placoderms in the Jaekelian sense, were considered to be true fishes.[1] It was further maintained by the same author on more than one occasion that Coccosteans are ancestral to Chimaeroids, an opinion that may be compared with Newberry's idea that Protopterus and Lepidosiren are modern survivals of Dinichthys.[2] Newberry and Jaekel thus stand alone in the recognition of any descendants of Arthrodires.

We may now pass rapidly in review the minor fluctuations of opinion that are apparent during the last few years. Dr. O. P. Hay, in his Catalogue of fossil Vertebrata of North America (1902), employs the term Placodermi for both Arthrodires and Asterolepids, placing them in the same subclass as Dipnoans. Arthrodires and Ostracophores are awarded each the rank of a separate subclass in the English edition of von Zittel's Textbook of paleontology, the author having discountenanced an association between Coccosteans and Dipnoans. In a remarkable paper by C. T. Regan, published in 1904, the Placodermi are re-established so as to include the Coccosteidae, Asterolepidae, and Cephalaspidae, all being united in a single order of Teleostomes. During the same year Professor Bridge expressed the view, in the volume on Fishes in the Cambridge natural history, that Coccosteans are "a highly specialized race of primitive Teleostomi," and compared their cranial roof-plates with those of typical bony fishes. Both in this work and in an elaborate monograph on the skull in modern Dipnoans, this author dissents emphatically from the opinion that Arthrodires and lung-fishes are at all closely related. Thus, in the volume on Fishes, at page 537, we read as follows: —

"The Arthrodira have been regarded as armoured Dipneusti, a view which is mainly based on their supposed autostylism and the nature of the dentition. But this autostylism has yet to be verified, and, if proved, the possibility that it may be a secondary feature, associated with the evolution of a peculiar dentition, must not be forgotten. Much more may be said for their claim to be regarded as a highly specialized race of primitive Teleostomi. Besides a well-developed lower jaw, bones comparable to the elements of a secondary upper jaw are known, and in a general way the disposition of the cranial roofing bones, and the arrangement of the endoskeletal elements of the pelvic fins, tend to conform to the normal Teleostome type. In fact, Dr. Traquair has expressed the opinion that the Arthrodira are Teleostomi and Actinopterygii."[3]

[1] Jaekel, O. Ueber die Organisation und systematische Stellung der Asterolepiden. Zeit. Deutsch. Geol. Gesell., 1903, **55**, p. 55.

[2] Newberry, J. S. Rept. Geol. Surv. Ohio. Paleont., 1875, **2**, p. 15.

[3] In his latest reference to this subject, however, they are stated by Traquair to be of uncertain subclass. *Cf.* Trans. Roy. Soc. Edinb., 1903, **40**, p. 732.

In two articles on Dinichthyid remains, published in 1905, Mr. L. Hussakof[1] refers to them as "Placoderms," evidently using the term in its familiar acceptation. Their position is also left undetermined by Prof. E. Ray Lankester, in his interesting lectures on Extinct animals, recently published.[2] Dr. F. A. Lucas's popular treatise on Animals before man in North America places them in association with lung-fishes, in accordance with Smith Woodward's ideas. One other popular handbook claims attention, not only because it is an extremely useful work covering the whole subject of fishes, but also because of the author's acquaintance with fossil as well as recent forms. We refer to President D. S. Jordan's Guide to the study of fishes (New York, 1905), in the first volume of which (page 582) the relations of Arthrodires are discussed as follows: —

"These monstrous creatures have been considered by Woodward and others as mailed Dipnoans, but their singular jaws are quite unlike those of the *Dipneusti*, and very remote from any structures in the ordinary fish. The turtle-like mandibles seem to be formed of dermal elements, in which there lies little homology to the jaws of a fish and not much more with the jaws of Dipnoan or shark.

The relations with the Ostracophores are certainly remote, though nothing else seems to be any nearer. They have no affinity with the true Ganoids, to which vaguely limited group many writers have attached them. Nor is there any sure foundation to the view adopted by Woodward, that they are to be considered as armored offshoots of the Dipnoans."

Again, at page 445 of the same volume, occurs this passage: —

"These creatures have been often called ganoids, but with the true ganoids like the garpike they have seemingly nothing in common. They are also different from the Ostracophores. To regard them with Woodward as derived from ancestral Dipnoans is to give a possible guess as to their origin, and a very unsatisfactory guess at that."

Finally, reference may be made to a paper published early in the present year, in which the writer[3] endeavored to show that the dentition of Arthrodires belongs distinctly to the Dipnoan type, and that real homologies exist between their cranial roof-plates and those of the living Neoceratodus. Indeed, the modern form was held to bear as intimate structural resemblance to Coccosteans on the one hand, as

[1] Hussakof, L. Notes on the Devonian "Placoderm," Dinichthys intermedius Newb. Bull. Amer. Mus. Nat. Hist., 1905, **21**, p. 27–36. On the structure of two imperfectly known Dinichthyids. *Ibid.*, p. 409–414.

[2] Lankester, E. R. Extinct animals. New York, 1905, p. 256.

[3] Eastman, C. R. Dipnoan affinities of Arthrodires. Amer. Journ. Sci., 1906, ser. 4, **21**, p. 77–89.

to Ctenodipterines on the other, although conforming in certain respects more closely than either to the hypothetical common ancestor from which all three types — Ceratodonts, Arthrodires, and Ctenodipterines — have been derived.

The position maintained in this last communication is adhered to, and it is believed that sufficient evidence has now been accumulated to sustain its correctness. Heretofore, in default of positive evidence, writers have been unable to demonstrate the truth of any one of the various conjectures put forward to explain the nature of Arthrodires. However plausible one or another of these may have appeared, however firmly they have been insisted upon, it must be remembered that a suggestion remains only a suggestion, and an hypothesis an hypothesis, until its correctness is clearly proved. Not without reason is it observed in one of the Socratic dialogues, that "mere beliefs and opinions are, like the statues of Daedalus, runaway things; not until they have been tied down by the chain of causal sequence do they stand fast and become in the true sense knowledge." (*Meno*, 159 D).

What constitutes "reasoned interconnection," as Plato calls it, in the present case, lies in the recognition of actual, definite, and precise homologies between Arthrodires and typical Dipnoans, which have hitherto escaped attention. That the significance of certain Arthrodiran characters has not been fully appreciated heretofore is due in large measure to the lack of sufficiently instructive material; and in part, also, to wrong interpretation of existing materials. By a fortunate chance the former of these deficiencies is now remedied, valuable enlightenment being afforded by the type of a new genus of Arthrodires from the Portage of western New York, presently to be described under the name of Dinomylostoma. It is hoped, also, that the second of these difficulties may be removed by means of a novel interpretation of the jaw-parts of Coccosteans and Mylostomids, such as is hereinafter set forth. Altogether, it would appear that a sound basis is now provided for upholding the following general propositions: —

1. Cranial roof-plates have undergone corresponding reduction and have become arranged after essentially the same pattern, both in Arthrodires and primitive Ceratodonts.

2. Neoceratodus recalls throughout its entire organization, save only for the absence of body armoring, the principal features of Arthrodires; resemblances which form too large an aggregate to be explained through parallelism.

3. It is impossible to regard Neoceratodus as the degenerate de-

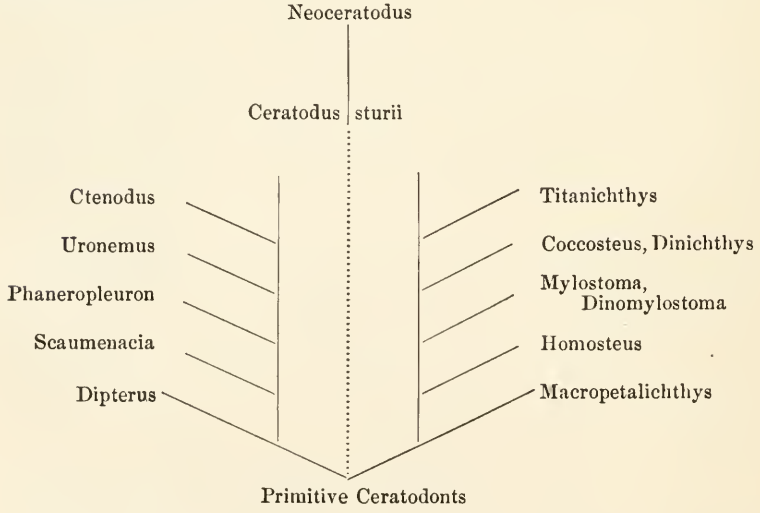
scendant of *both* Ctenodipterines and Arthrodires, nor of either group to the exclusion of the other. Since, however, it partakes of the characters of both, community of origin is necessarily presupposed for all three groups.

4. Arthrodires and Ctenodipterines may be regarded as specialized offshoots which diverged in different directions from the primal Dipnoan stem; and only the more generalized descendants of the original stock have continued to survive until modern times.

5. The primordial stock must have been autostylic, diphycercal, without a secondary upper jaw and dentigerous dentary elements, and with a Uronemus-like or Dipterus-like dentition; characters which do not permit us to ascribe the ultimate origin of Dipnoans to the Crossopterygii, but suggest rather a descent from Pleuracanthus-like sharks.

6. The recognition of Arthrodires as an order of Dipneusti precludes their association with Ostracophores in any sense whatever. The recently revived group of "Placodermata" is, therefore, an unnatural assemblage and should be abandoned.

7. In the light of present information, progressive modifications amongst early Dipnoans may be represented graphically after some such scheme as follows: —



With this statement of the general nature of the problem, our task is to substantiate the claim in regard to the close structural agreement

between Arthrodires and Ceratodonts. First and most important of all, the characters furnished by the dentition may be considered; and we shall endeavor to show that Dinichthys and Mylostoma represent the same modifications in the ancient fauna as are displayed by Protopterus and Neoceratodus in the recent, so far as dental characters are concerned.

Dentition of Dinichthys and Neoceratodus compared. — It is admitted by all writers that Neoceratodus, as compared with the two other surviving genera of lung-fishes, represents a relatively early larval stage of development; nor is it questioned by any one that the trenchant dental plates of Protopterus and Lepidosiren are not mere variants of the Ceratodont type. This much being already clear, it is but a short step further to see that the dentition of Coccosteus and Dinichthys has been similarly derived. Certainly no difficulty is offered by the so-called "premaxillary" teeth of Dinichthys, which are the precise equivalent of the vomerine pair in modern Dipnoans, as was long ago pointed out by Dr. Theodore Gill.[1] As for the characteristic tritoral plates in upper and lower jaws of Ceratodonts, these occur normally in Mylostoma, but in Dinichthys have become rotated so as to stand upright in the jaws, their outer denticulated margins functioning against one another like the blades of a pair of shears. An inkling as to how this variation was brought about is afforded by the Triassic *Ceratodus sturii* Teller,[2] which may be taken to represent an incipient stage of metamorphosis. The dental plates of this form are seen to be turned more or less on edge, the corrugations interlocking in opposite jaws when the mouth is closed, and a rudimentary beak being developed in front which recalls the well-known tooth-like projection in Dinichthyid mandibles.

As for the so-called "maxillary" or "shear-tooth" of Dinichthys, this corresponds plainly to the triturating upper (palato-pterygoid) dental plates of Ceratodonts, turned rather more upright than in *C. sturii*; and its anterior process or "shoulder" is represented by the forwardly placed ascending process of modern forms.

The functional lower jaw of Arthrodires agrees with that of other Dipnoans in that the mandibular dental plate is supported solely by the splenial, and no true dentary element is present. The Ctenodipterine mandible, as compared with that of other *Dipneusti*, is the most complicated, being composed of a greater number of pieces, more extensively ossified, and covered externally with a ganoine investment. Consider-

[1] Rept. Geol. Surv. Ohio. Paleont., 1875, **2**, p. 7.

[2] Teller, F. Ueber den Schädel eines fossilen Dipnoërs. Abhandl. k. k. Reichsanst., Wien, 1891, **15**, Plate iv.

able simplification is to be observed amongst modern Sirenoids, in that the articular element is not differentiated from the Meckelian cartilage, the ensheathing angular has become reduced in the two more specialized genera to a mere splint-like rudiment, and in the same genera the flat triangular piece called by Huxley the "dentary," by Fürbringer[1] the "submandibular," has disappeared entirely. Still further reduction is evident amongst Arthrodires, where there are no bones ensheathing Meckel's cartilage externally, and the only ossifications thus far recognized consist of the splenial and mandibular dental plate. All the best known genera display a conspicuous groove along the antero-inferior border of the splenial, passing underneath and to the inner side of the dental plate proper, and terminating a little short of the symphysis. Its general appearance, position, and direction at once recall the very similar groove in Protopterus, hence it is natural to attribute to it a corresponding function. In it were lodged remnants of the Meckelian cartilage, precisely as in living forms.[2]

The suggestion has been made by one or two recent writers that the jaws of Arthrodires are non-homologous with those of ordinary fishes. Dean, for instance, supposes them to have originated from merely dermal ossifications, and to be in nowise derived from visceral arches. Unessential structural differences, and assumed functional differences, such as mobility of the mandibular rami in a manner wholly unique amongst Chordates, are urged in support of this novel idea. Whether we compare the Arthrodiran lower jaw with that of Ctenodipterines, as Sagenodus,[3] for example, or of modern Sirenoids, the obvious similarity of all the parts, relations of the Meckelian cartilage, and insensible transition between the splenial and mandibular dental plate as regards

[1] Fürbringer, K. Beiträge zur Morphologie des Skeletes der Dipnoer, etc. Semon's Zool. Forschungsreisen in Australien. Jena Denkschr., 1904, **4**, p. 442. Miall and Traquair employ Huxley's designation; the same element is also named "predentale" by Van Wije, and "dermomentale" by Fritsch. Its origin appears to be conditioned by the presence of mandibular sensory canals, the bone being formed around them. When canals are lacking, as in *Protopterus* and Arthrodires, no submandibular occurs.

[2] Fürbringer, K. *Op. cit.*, p. 481, Plate 39, Fig. 28. Wiedersheim, R., Morpholog. Studien. Jena, 1880, **1**, p. 55, Plate 2, Figs. 3, 8.

[3] The splenial, for instance, is notably elongated in the form figured by T. Atthey under the name of *Ctenodus obliquus* in the Ann. Mag. Nat. Hist., 1875, ser. 4, **15**, p. 390, Plate 19, Fig. 2. By Smith Woodward this species is considered identical with *Sagenodus inaequalis* Owen. In *Sagenodus pertenuis*, from the Permian of America and Russia, the dental plates develop sharp cutting edges. See Amer. Nat., 1904, **37**, p. 493–495.

microscopic structure,[1] demonstrate in clearest possible manner that definite homologies exist. Not only can there be no question as to real homology, but it is further evident that one general type of mandible is common to all Dipnoans, only amongst Arthrodires this type is resolved to its simplest terms. So far as the present writer is aware, no adequate cause has been shown for supposing that the jaws of Arthrodires were capable of anomalous movements, and the notion that the mandibular rami were not rigidly united with each other at the symphysis may be regarded as slender as the seven lean kine. That the vomerine teeth, at least, were immovably attached to the headshield is proved by their occasional fusion with it in Dinichthys, as in a specimen belonging to the British Museum (Cat. No. P 9490), and presumably also in the complete skull described by Newberry[2] "with the great premaxillary teeth in place," immediately behind which were the "maxillaries." There can be no question that the upper pavement dentition of Mylostomids was absolutely fixed. Under such conditions it is inconceivable that the mandibular rami were capable of torsion, and of separation and approximation from each other at their anterior extremities. But it has been argued that such movements are implied by the presence of symphysial denticles in forms like Coccosteus and Diplognathus. The logic involved does not appear to be particularly convincing. In the first place it is uncertain whether these denticles were really functional. And in the second place, even if they were, their origin is best explained as a reminiscence of primitive conditions, such as are to be inferred from the ontogeny of Neoceratodus.[3]

Dentition of Mylostoma and Neoceratodus compared. — The large tritoral upper dental plates of Mylostoma present such an obvious similarity to the well-known crushing plates of typical Dipnoans that, supposing

[1] It has been shown by Claypole in the Proc. Amer. Micros. Soc., 1894, **15**, p. 189–191, that the functional margin of a jaw element in Dinichthys differs from the remaining portion (splenial) only in its denser structure. Identical conditions exist amongst fossil and recent Dipnoans. Thus Günther, in his description of Neoceratodus, remarks that the substance of the splenial "passes so gradually into that of the tooth that it is only by the difference in shade of color that the boundary line between osseous base and dentinal crown is indicated. . . . In our specimens the structure of the bony base of the tooth differs in nothing from that of the remainder of the dentary bone [*i. e.*, splenial]: there is the same spongeous structure, the same proportion of bone-corpuscles, etc." — Phil. Trans., 1871, **161**, p. 519.

[2] Newberry, J. S. Monogr. U. S. Geol. Surv., 1889, **16**, p. 146.

[3] Semon, R. Die Zahnentwickelung des Ceratodus forsteri. Sitz. Gesell. Morph. Phys. München, 1899, **15**, p. 75–85. Also Zool. Forschungsreisen in Australien. Jena Denkschr., 1901, **4**, p. 115–133.

they had always been found in the detached condition, without being associated with a Dinichthys-like mandible or other parts suggestive of Arthrodires, no one would question the propriety of referring them to Dipnoans. In general form, mode of attachment, and microscopic structure, they differ in nowise from the characteristic palato-pterygoid dentition of lung-fishes. If it be objected that they have neither tuberculated surfaces nor crenulated outer margins, it must be remembered that various Dipnoan genera are known which have perfectly smooth dental plates. The plates themselves, therefore, reveal no characters which enable us to distinguish them from the Dipnoan type of upper dentition.

It has been demonstrated, however, in the most convincing manner, that these upper tritoral plates of Mylostoma belong to Arthrodiran fishes essentially like Dinichthys, except that the dentition is adapted for crushing instead of cutting; in other words, the two genera mentioned present an interesting parallel, as regards their dentition, to the modern Neoceratodus and Protopterus. It follows as a matter of course that the jaw-parts of the two recent and the two fossil genera must be respectively homologous, inasmuch as common ancestry is implied for the members of either pair. Great as may appear at first sight the differences between the Mylostoma and Dinichthys form of dentition, they are nevertheless reducible to a common plan, and this common plan is identical with that typified by Neoceratodus. In the first place it is to be noted that the two Arthrodiran genera under comparison have a single, and somewhat similar, pair of vomerine teeth, as do also modern Dipnoans. Next it will be observed that a like form of mandible is present in both genera, bating only that in Mylostoma the dental plate lies horizontally expanded, and in Dinichthys it is turned vertically, so that what was formerly the denticulated outer margin now becomes the functional cutting edge. There remains finally the palatal dentition to be considered, and here the fact requires explanation that two tritoral pairs of dental plates occur behind the vomerines in Mylostoma, as opposed to the single pair of "shear-teeth" in Dinichthys, which have already been interpreted as the morphological equivalent of the palato-pterygoid dental plates of Ceratodonts. Enlightenment on this point is furnished by the ontogeny of Neoceratodus, which teaches that the discrepancy is more apparent than real; for, as shown by Semon,[1] the dental plates of the modern genus arise through concrescence of conical denticles, which are at first disposed so as to form two pairs of palato-pterygoid

[1] *Loc. cit.*, 1899, and 1901.

plates, arranged as in Mylostoma, these afterwards fusing into one. Neoceratodus therefore reproduces ephemerally a stage which remains permanent in the Devonian genus, and is probably to be regarded as an inheritance of primitive conditions.

Sufficient arguments have now been given, we think, to support the claim that the dentition of Mylostoma and Dinichthys is constructed distinctly upon the Dipnoan type. We learn from recent forms that the external ensheathing bones of the mandible may become greatly reduced. In the Arthrodiran jaw this process has merely been carried a little further than in Protopterus. The presence of a supernumerary pair of dental plates in Mylostoma is satisfactorily accounted for by the ontogeny of Neoceratodus, which reveals the primitive nature of Mylostomid type of dentition, and suggests for it a common origin with the Ceratodont. Indeed, the evidence derived from this latter source shows that Mylostoma has departed less widely from primitive Ceratodonts with respect to its dentition than have true Dipterines; for amongst the latter no vomerine teeth occur, nor is any form known which has retained more than a single pair of palato-pterygoid dental plates, whereas their ancestors may reasonably be presumed to have had two. This point is in harmony with other facts making for the conclusion that modern lung-fishes are not directly descended from Dipterines.

Cranial characters indicating Dipnoan affinities of Arthrodires. — From the interpretation of jaw-parts just given, it is obvious that no secondary upper jaw occurs amongst Arthrodires. Certainly the suborbital, which is simply a cheek-plate, has nothing whatever in common with a maxillary arch, nor is there the slightest reason for believing that it supported, or was otherwise associated with, or even in contact with the "shear-tooth" in Dinichthys. Aside from the suborbital and dental elements already accounted for, there are absolutely no plates left which can by the greatest stretch of imagination be homologized with the maxillae and premaxillae of ordinary fishes. We are therefore prohibited from classing Arthrodires amongst Teleostomes, and at the same time must recognize their agreement with Dipnoans in one of their most distinctive characteristics.

Another important fact must also be considered. It is well understood that the cranial roofing-bones of modern lung-fishes are not readily to be homologized with those of Ctenodipterines, or indeed of any other group with the exception of Arthrodires. Now, how are we to explain this remarkable coincidence except upon the hypothesis of common

descent? It may be well at this point to inquire into the question of homologies a little more fully.

Various Arthrodiran genera may be selected for comparison with Neoceratodus, and the cranial structure of the two types be examined in most critical light; it will be found that intimate correspondence exists throughout. Inasmuch, therefore, as the skull of typical Arthrodires was constructed upon essentially the same model as in Neoceratodus, the latter becomes a standard for interpreting certain minor details which have hitherto been misunderstood. These we shall have occasion to refer to presently. In comparing the cranial pattern of the Ceratodont and Arthrodiran type, it will not do to confine our attention to any one genus of the latter; we must consider the range of variation exhibited by the group as a whole. Thus, at first sight, it would seem almost impossible to coördinate the median series of plates in Neoceratodus (Fig. B) with those of Dinichthys (Fig. A), although the lateral

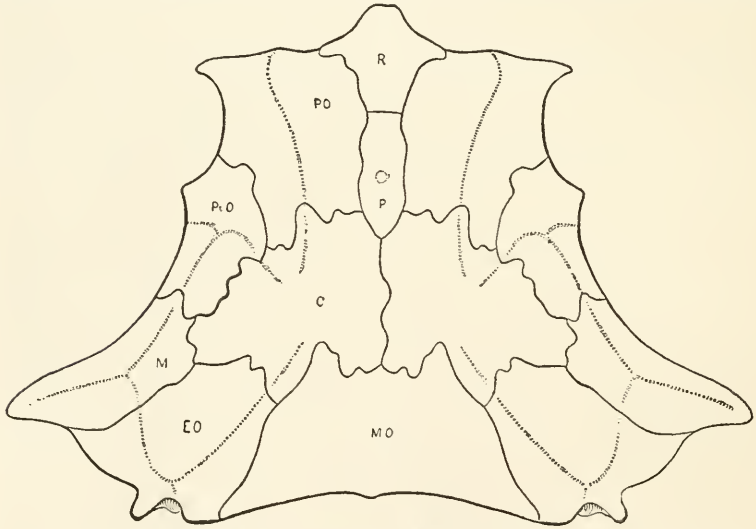


FIG. *A.* — *Dinichthys pustulosus* Eastman. Middle Devonian; Iowa. Restoration of the headshield, dorsal aspect, × ¼. C, central; EO, external occipital; M, marginal; MO, median occipital; P, pineal; PO, preorbital; PtO, postorbital; R, rostral or mesethmoid. Sensory canals represented by double dotted lines. Suborbital omitted.

series stand in sensible agreement. The equation is readily solved, however, by substituting Macropetalichthys in place of Dinichthys as an intermediate term of comparison, on the principle that things equal to the same thing are equal to each other. Both in Macropetalichthys and

Neoceratodus the median series is reduced to one anterior element, covering the pineal and rostral (or ethmoid) regions, and one elongated posterior element (*M O*), these two plates being suturally united with each other, and excluding the paired central elements from contact along the median line. Nevertheless in Protopterus the plates corresponding to the centrals are actually in apposition along the median

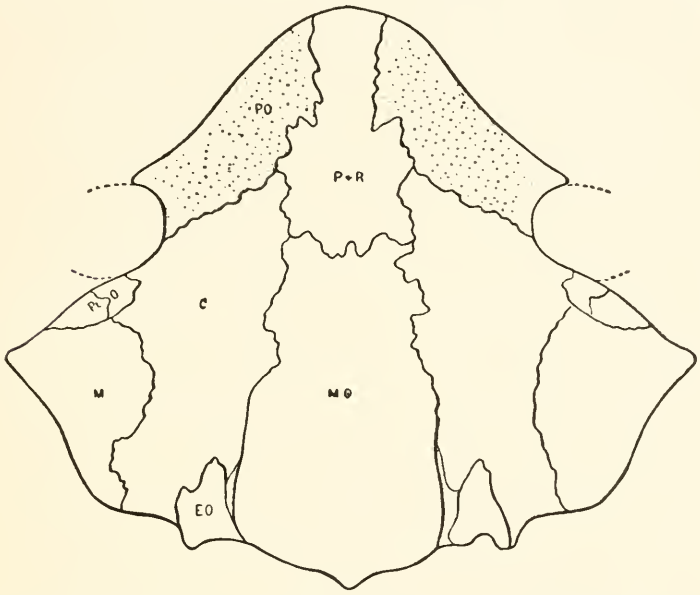


FIG. *B*. — *Neoceratodus forsteri* (Krefft). Dorsal aspect of cranial roof, drawn as if flattened out, and dermal plates lettered to correspond with those in Dinichthys. Cartilaginous elements (PO) dotted; suborbitals omitted. From a specimen in M. C. Z., × ½.

line for a certain distance anteriorly, and in Homosteus the median occipital is relatively more elongated than in Neoceratodus. The latter shows an abrupt downward deflection of the bone-substance along a portion of the posterior margin of the cranial roof. Like conditions are found in Macropetalichthys, even more conspicuously developed. Macropetalichthys and Homosteus both have the external occipital greatly enlarged at the expense of the central elements. Neoceratodus, on the other hand, has the centrals enlarged at the expense of the external occipitals (Fig. *B*, *EO*). In *Ceratodus sturii* these plates are more nearly as in Dinichthys.

The remaining elements of the cranial roof in Neoceratodus are easily

coördinated with those of typical Coccosteans, allowance being made for the fact that the preorbital in the modern form appears to have reverted to its primitive cartilaginous condition. Similar instances of reversion, or degeneration of membrane-bones, occur among Chondrosteans and Teleosts. A tendency toward reversion would seem to be indicated also by the external occipital along its inner border, and the small plates surrounding the orbits show imperfect ossification. The latter, according to the observations of Huxley, Traquair, and others, are sometimes inconstant in number, the suborbitals tending to become fused into a single piece not unlike that of typical Coccosteans (*cf.* Figs. C, D). The postorbitals of Neoceratodus are interpreted by Bridge[1] as remnants of an obsolescent supraorbital ring; by Fürbringer[2] as bones that have become newly formed about the sensory canals bounding the orbit, yet belonging properly to the cranial roof. The explanation here offered is that they are equivalent to the single large postorbital occurring on either side of the headshield in Arthrodires.

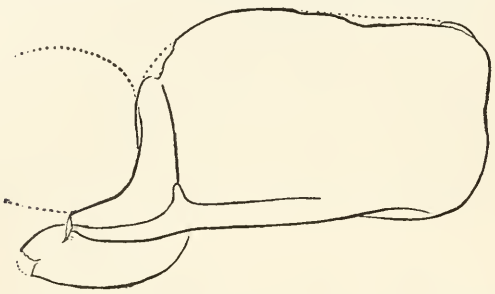


FIG. *C.* — Left suborbital plate of *Dinichthys terrelli* Newb., from the Cleveland shale of Ohio. External aspect, × ⅓.

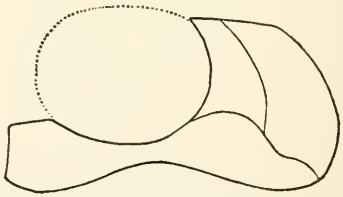


FIG. *D.* — The three plates forming collectively the suborbital of *Neoceratodus forsteri* (Krefft), drawn from the same specimen as shown in Fig. A. × ½.

Unlike Ctenodipterines, Neoceratodus retains throughout life a completely closed and almost entirely unossified chondrocranium, and this notable peculiarity would seem to be shared also by most Arthrodires. In Chelyophorus, however, two small ossifications occur in a position corresponding to the exoccipitals, and have been interpreted as such by Smith Woodward.[3] A somewhat

[1] Bridge, T. W. Morphology of the skull in Lepidosiren, etc. Trans. Zool. Soc. London, 1898, **14**, p. 355.

[2] Fürbringer, K. Beiträge zur Morphologie des Skeletes der Dipnoer. Jena Denkschr., 1904, **4**, p. 445.

[3] Woodward, A. S. Catalogue fossil fishes British Museum, 1891, pt. 2, p. 280.

nearer approach to Ctenodipterine conditions has been noted by Cope[1] in Macropetalichthys, where the space occupied by the chondrocranium is closed posteriorly by a thin osseous septum extending transversely across the headshield, and pierced in the middle by a triangular opening for passage of the notochord. The same genus is further remarkable for having a partially ossified parasphenoid, which is produced posteriorly beyond the transverse septum referred to as far as the hinder margin of the headshield, and supports the forward portion of the vertebral axis in a manner analogous to that in Neoceratodus and sturgeons. Mention may also be made in this connection of an undescribed Coccostean from the Devonian of Wildungen, which, according to Jaekel,[2] shows traces of an "echte Schädelkapsel mit deutlichem Occiput und Foramen magnum." Aside from these instances, no ossifications are known within the interior of the headshield of Arthrodires which can be associated with the chondrocranium. The presence of a pineal gland is distinctly indicated in most forms, its position being as in Neoceratodus.

Another point of resemblance between Arthrodires and typical Dipnoans is found in the disposition of the external nares. Dipnoans represent an advance over Elasmobranchs in that the oro-nasal grooves of the latter are converted into true nasal passages, and the olfactory pits communicate with the mouth by internal nostrils as in higher vertebrates. This modification is evidently to be associated with air-breathing habits, and, as pointed out by Huxley[3], suggests that the sense of smell is of value to these creatures. The occurrence of internal narial openings amongst Arthrodires would coincide with other evidence indicating Dipnoan relationships, and we may even attempt to define their position in at least one genus, as will be noted in the description of Dinomylostoma (p. 27). The large size of the supposed olfactory capsules in Dinichthys[4] may also be considered as implying a tolerably keen perception of odoriferous particles, which is dependent upon the

[1] Cope, E. D. On the characters of some Palaeozoic fishes. Proc. U. S. Nat. Museum, 1891, **14**, p. 453, Plate 29, Fig. 4, Plate 30, Fig. 5.

[2] Jaekel, O. Ueber die Organisation und systematische Stellung der Asterolepiden. Zeitschr. Deutsch. Geol. Gesell., 1903, **55**, p. 48.

[3] Huxley, T. H. On Ceratodus forsteri, etc. Proc. Zool. Soc. London, 1876, p. 27. Position of the anterior nasal apertures in Lepidosiren. *Ibid.*, p. 180.

[4] These are described as "optic capsules" by Newberry in his Monograph on the Palaeozoic fishes of North America, p. 146, Plate 7, Figs. 2, 2*a*. They are stated to occur "not always in the same position, but they were two in number, one on each side, and located well within and near the anterior extremity of the head."

act of sniffing; and this function can only be performed effectually when posterior nasal apertures are present.

There remains finally the somewhat difficult task of homologizing the opercular elements in Arthrodires and Dipnoans: difficult, because more than one interpretation is open to us, and we cannot be entirely certain as to which plate or plates of the Coccostean skeleton corresponds to the two opercular bones found in typical Dipnoans. It is a well-known fact that the suborbital in Coccosteus is succeeded behind by a small, deep, semi-elliptical plate with free hinder margin, although no such bone has been found in Dinichthys, and in Neoceratodus the corresponding space is filled by cartilage or fibrous tissue. The branchial aperture does not occur in this vicinity in the modern form, but is placed considerably further back. The doubtful element referred to in Coccosteus is lettered "*x*" in Woodward's restoration of that genus, "*j*" in Traquair's, and in Jaekel's it is unmarked. The first-named author suggests that it is "not improbably to be regarded as the operculum;"[1] Traquair interprets it as jugal;[2] Jaekel as quadrato-jugal.[3] Against its interpretation as an operculum it may be argued that the bone in question is of disproportionally small size; is situated relatively too far forwards, where we should expect the side wall of the head to be closed; is unaccompanied by any subjacent element answering to the suboperculum; and has apparently no equivalent amongst other Arthrodires. In Dinichthys, the corresponding space is covered by the posterior portion of the suborbital, which extends as far as the postero-lateral angles of the headshield, and is in close proximity below with the so-called "clavicular." Judging from this fact, and from the conditions observed in Neoceratodus, it seems preferable to regard the bone "*x*" in Coccosteus merely as an intercalary piece which may exist occasionally as a separate ossification, and serves to protect the side of the head. The consequence of this view is that we shall be compelled to search, as Jaekel has done, for the operculum and suboperculum amongst plates forming part of the lateral armoring of the trunk.

According to Jaekel's idea (*loc. cit.*, p. 109), the opercular elements

[1] Woodward. A. S. Catalogue fossil fishes British Museum, 1891, pt. 2, p. 280, Fig. 44.

[2] Traquair, R. H. On the structure of Coccosteus decipiens Agassiz. Ann. Mag. Nat. Hist., 1890, ser. 6, **5**, p. 127, Plate 10, Figs. 1, 2.

[3] Jaekel, O. Ueber Coccosteus und die Beurtheilung der Placodermen. Sitz. Gesell. Nat. Freunde, 1902, p. 108 (restoration, p. 107).

of Coccosteus are to be sought in the plates which Traquair has named antero-lateral and antero-dorso-lateral. This identification we are prepared to accept in part only. The antero-dorso-lateral, we believe, must be excluded from association with opercular elements, on account of differences in form and relative position; because it is articulated with the headshield; and also because its dorsal and ventral margins are overlapped by contiguous plates. Besides, it is traversed by sensory canals in a manner quite unusual for the operculum.

Otherwise is the case with the antero-lateral, or "clavicular," as the corresponding plate is called in Dinichthys. It has a somewhat similar configuration, is of about the some relative size, and occupies the same relative position both in these genera and in Neoceratodus. Its upper portion overlaps the postero-lateral margin of the headshield for a short distance behind the prominent postero-lateral angles, and its lower front portion extends forward so as to continue the contour of the lower jaw with scarcely appreciable interruption. Another important fact to be observed is that this plate, both in Coccosteus and Dinichthys, occurs in association with a small rod-shaped or spiniform piece, lying immediately underneath, which is highly suggestive of the suboperculum in typical Dipnoans. First observed in Brachydirus, where for lack of a more appropriate name it was called "Ruderorgan" by von Koenen, this bone was afterwards detected in two species of Coccosteus by Traquair, who named it "lateral spine," and compared it with the fixed spinous appendage of Phlyctaenaspis and Acanthaspis.[1] We misdoubt greatly whether the implied homology exists. Rather it seems to us that the fixed spinous appendage of the two last-named genera should be regarded as an elongated process of the ventral system of plates, whereas in Coccosteus, Brachydirus, and Dinichthys the lateral spine (= "pectoral fin-spine" of Newberry) is free, and meets all theoretical requirements for a suboperculum. There is reason to believe, therefore, that the antero-lateral and "lateral spine" of Coccosteans correspond, respectively, to the operculum and suboperculum of typical Dipnoans; and the branchial aperture may be supposed to have been placed in the prominent sinus formed by the lateral armoring of the trunk immediately behind these plates. This is also the region where we should expect pectoral fins to have been attached, were such structures devel-

[1] Traquair, R. H. Notes on the Devonian fishes of Campbelltown, etc. Geol. Mag., 1893, ser. 3, **10**, p. 149. Notes on Palaeozoic fishes. Ann. Mag. Nat. Hist., 1894, ser. 6, **14**, p. 370. These are apparently the references alluded to by Jaekel in the postscript to his paper on Coccosteus, *loc. cit.*, p. 115.

oped. It is at least where traces of them should be looked for amongst the most primitive genera.

Autostyly. — No Arthrodire thus far discovered can be definitely proved to have been autostylic. This type of cranial structure is to be inferred, however, (1) from concurrent testimony of other characters pointing to Dipnoan relationships; (2) from the remarkable similarity of the jaw-parts to those of modern Dipneusti; (3) from the absence of any ossification which can be interpreted as hyomandibular, even in the most exquisitely preserved skeletons; (4) from the occurrence of articular cartilage in natural association with the lower jaw of Dinomylostoma; and (5) from the position and appearance of a pair of well-marked fossae on the under side of the head in Macropetalichthys, described by Cope as "an articular glenoid cavity, possibly for the condyle of a mandible."[1] Regarding these latter structures, it need only be remarked that Cope's interpretation is materially strengthened by the resemblance between the fossae and certain facets for articulation with the mandible as seen in the quadrate element of Dipterus;[2] a resemblance which serves, by the way, to emphasize the close approach made by this extremely generalized form to Ctenodipterine conditions. Macropetalichthys offers in many ways a fair presentment of an ancestral, synthetic type.

We may conclude this phase of the subject by calling to mind the caution that Dollo and Bridge have urged against attributing too great significance to the occurrence of autostyly amongst fishes. Reasons have been given by these authors for believing that the nature of the suspensorium must not necessarily be regarded as an indication of genetic affinity, and that autostyly is a purely adaptive modification. Thus, it is held by Bridge that the autostylic condition of the skull "may occur independently in diverse groups of Fishes wherever any advantage is to be gained from the fixation by fusion to the skull of the primitive elements of the upper jaw (palato-quadrate cartilage) for the purpose of providing the needful support for a massive and peculiar dentition, or even, as I have suggested above, for a system of labial cartilages in a suctorial mouth."[3] In the opinion of the writer last quoted, it is imma-

[1] Cope, E. D. On the characters of some Palaeozoic fishes. Proc. U. S. Nat. Mus., 1891, **14**, p. 453.

[2] Traquair, R. H. On the genera Dipterus, etc. Ann. Mag. Nat. Hist., 1878, ser. 5, **2**, p. 5, Plate 3, Figs. 1–4.

[3] Bridge, T. W. On the morphology of the skull in the Paraguayan Lepidosiren. Trans. Zool. Soc. London, 1898, **14**, p. 372.

terial whether Arthrodires were autostylic or hyostylic; the ultimate proof of their Dipnoan relationships must rest on other characters than these. Fürbringer's commentary on the views just stated will be found on page 501 of his monograph on the skeleton of Dipnoans to which we have several times referred.

Body characters indicating Dipnoan affinities of Arthrodires. — It is safe to affirm that the main outlines of the skeletal structure of Arthrodires, except only for the development of dermal armor, agrees intimately with those of recent Dipnoans. A certain amount of resemblance might be explained as due to parallelism; but no such theory can account for the striking coincidence in structural plan to be observed throughout all parts of the body. It would be absurd to suppose that one group of organisms, such as Arthrodires, coincides fortuitously with the principal features of another group, — as, for example, Ceratodonts — without the two being nearly related. When it is realized that essential unity of structural type pervades not only the cranium but the entire skeleton of the groups mentioned, the obvious inference to be drawn is that they share a common origin. This is a legitimate, and, indeed, unavoidable deduction. We might even proceed further, and, if one cared to speculate as to the ultimate origin of Dipnoans, a number of characters would be found suggesting descent from Pleuracanthus-like sharks.[1]

The body characters in which Arthrodires may be claimed chiefly to resemble modern Dipnoans are as follows: (1) a persistent notochord; (2) diphycercal tail; (3) segmental correspondence between the skeletal supports of the soft dorsal fin and the vertebral axis, to the extent that the two sets of interspinous bones are articulated with each other and also with the neurapophyses by expanded extremities, there being an equal number of interneurals and neural spines; (4) punctate dermal plates; and (5) — although this last point requires further confirmation — an apparently similar conformation of the pelvic arch.

On the other hand, the following points of difference are to be noted between Arthrodires and modern lung-fishes: (1) encasement of the anterior portion of the trunk in dermal armor; (2) apparent atrophy of the anal and pectoral fins; and (3) shortening of the dorsal into a single, abbreviate, membranous fin situated in the middle of the back. None of these characters, however, are of fundamental importance,

[1] *Inter alia*, the notochordal axis, diphycercal tail, biserial pectoral fins, basipterygial pelvic girdle, and, most singular of all, the Dipnoan-like arrangement of dermal bones roofing the head.

representing as they do merely the specialization peculiar to Arthrodires. Their aggregate is of no greater taxonomic importance than the sum-total of differences between Ctenodipterines and Sirenoids. Quite the contrary, for the distinctions between Arthrodires and Ceratodonts are on the whole less trenchant than between the latter and Ctenodipterines. The one constant character in which all Ctenodipterines differ from existing Dipnoans is, as pointed out by Bridge, the multiplicity and almost Acipenseroid arrangement of their cranial roofing bones. Oddly enough, it is precisely this feature wherein a constant difference exists between the groups named, that a constant resemblance is to be noted between modern lung-fishes and Arthrodires. The cranial pattern of the two latter types is essentially identical, but anomalous as compared with all other vertebrates.

The differences between the Ctenodipterine and Sirenoid orders of *Dipneusti* have been tabulated by several writers, among whom it will be sufficient to mention Bridge and Fürbringer, in their monographs already several times quoted. By extending the range of comparison far enough to include Arthrodires as well, it will be observed that the two extinct orders (*i. e.*, Ctenodipterines and Arthrodires) agree with modern Dipnoans and differ from all other fishes in possessing the following combination of cranial characters[1]: —

1. The presence of characteristic tritoral or trenchant dental plates in upper and lower jaws, the former supported by palato-pterygoid elements, usually ossified, and the mandibular by the greatly developed splenial bones of the lower jaw.

2. The absence of maxillae and premaxillae in the upper, and of a true dentary bone in the lower jaw.

3. The presence of only two opercular bones, an operculum and an interoperculum, and the absence of a distinct preopercular element.

4. Complete and typical autostyly in at least the two more commonly recognized orders, and presumably in the Arthrodiran as well.

Structural Characters of Mylostomids.

Mylostoma was established by J. S. Newberry in 1883 upon the evidence of dissociated parts of the dentition, no specimen being known to him in which the dental elements were preserved in natural position or accompanied by other portions of the skeleton. Under these cir-

[1] See the remarks on this subject by Professor Bridge, in his Monograph on Lepidosiren, page 365.

cumstances it is not to be wondered that his descriptions were imperfect, and his ideas as to the systematic position of the genus confused. Newberry's original suggestion was that Mylostoma should be referred "to the group which includes Dipterus, Palædaphus, Ctenodus, and Ceratodus."[1] Six years later he included the genus under the head of "Placoderms," considering it to be an extremely specialized "member of the family of the Dinichthidae;"[2] yet on another page of the same work these fishes were defined as "Dipterine Ganoids of large size," and the points of resemblance between them and Ctenodipterines were considered "sufficient to justify the inference that they were all related."[3]

Without attempting a theoretical reconstruction of the Mylostomid type of dentition, Newberry was nevertheless convinced that it was extremely complicated. The beveled edges and other appearances of certain specimens were interpreted by him as indicating co-adaptation with contiguous elements, whence it followed that several pairs of dental plates must have been present in the lower jaw, and the upper dentition was supposed to be in the form of a "tesselated pavement consisting of many pairs of plates."[4] The author's own words with reference to the latter point are as follows: —

"The dental plates of the upper jaw form several pairs, of which the central and largest are rudely triangular in outline, with a flattened or concave triturating surface, bearing, as do some of the inferior teeth, evidences of wear. The surface of attachment to the cranium of these dental plates is flat or concave and somewhat rough, from the coarse cellular tissue of the bone; the sides are straight or beveled, apparently for co-adaptation, and by this character favor the conclusion that the dentition consisted of many pairs of plates, constituting a tesselated pavement; the crowns of the teeth below being convex, those above concave."

It was reserved for Dr. Bashford Dean[5] in 1893, and more completely in 1901, to disclose the essential characters of Mylostoma, and to demonstrate its close relation with Dinichthys, as the result of his study of an admirably preserved specimen of *M. variabile* from the Cleveland shale of Ohio. Eventually, one of the counterparts of this

[1] Newberry, J. S. Some interesting remains of fossil fishes, recently discovered. Trans. N. Y. Acad. Sci., 1883, **2**, p. 146.

[2] *Idem.*, Monogr. U. S. Geol. Surv., 1889, **16**, p. 163.

[3] *Ibid.*, pp. 161, 163.

[4] *Ibid.*, p. 165.

[5] Dean, B. On Trachosteus and Mylostoma, Notes on their Structural Characters. Abstract. Trans. N. Y. Acad. Sci., 1893, **12**, p. 70–71. Palæontological Notes: On the Characters of Mylostoma Newberry. Mem. N. Y. Acad. Sci., 1901, **2**, p. 101–109.

specimen was acquired by the Museum of Comparative Zoölogy at Cambridge, the other by the American Museum of Natural History, New York. One will readily appreciate the importance of this example when it is remembered that but one other Mylostomid is known in which nearly the complete dentition occurs in natural association with portions of the headshield and abdominal armor. The second specimen referred to will be found hereinafter described as the type of a distinct genus, Dinomylostoma.

The structural characters of Mylostoma have been worked out with such thoroughness and precision by Dean in his elaborate monograph of 1901, that it would be futile to attempt to supplement his descriptions. Only in a few particulars is a somewhat different reading of the original to be advocated than that which is preferred by him. Thus, the construction which we should place upon the dental elements of the upper jaw is indicated in Fig. E, the evidence for which rests

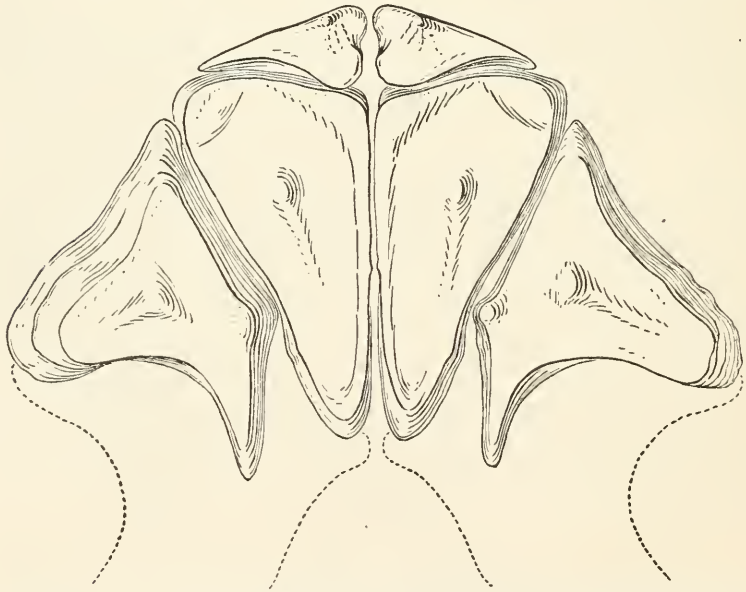


Fig. *E.* — Upper dentition of *Mylostoma variabile* Newb., from the Cleveland shale of Sheffield, Ohio. × ½.

upon the following considerations: — (1) In no other position is there such accurate fit between upper and lower dental plates when the jaws are closed; (2) it is the only arrangement which accounts at all points

for reciprocal marks of wear; (3) the reconstruction here shown is in harmony with ontogenetic evidence; and (4) the same disposition has been found to hold true also for Dinomylostoma (*vide infra*).

It may be noted further that there does not appear to be any certain trace of the median ventral plates, and in Dean's restoration of the ventral armor one perceives that the antero- and postero-ventro-laterals have been interchanged. The restoration of the headshield and configuration of the dorso-median plate, as shown in Dean's figure 3 must be understood as largely conjectural; and his statement that the orbits are "placed dorsally and somewhat closely together, characters which perhaps might be expected in a fish of ray-like habits," cannot be confirmed. Mylostoma agrees with Coccosteus and Dinichthys, rather than with Homosteus, as regards position of the orbits, and there is no indication that the body was depressed dorso-ventrally in any of these genera.

In Plates 1 and 2 are shown a number of palato-pterygoid plates belonging to *Mylostoma variabile*, some of which are type specimens; and in Plate 3 are represented two of the mandibular dental plates belonging to the same species (Figs. 19, 20), and also the type specimen of *M. terrelli* Newberry (Fig. 21). None of the originals selected for illustration seem to require further comment than will be found in the explanation of the plates. For having generously placed material belonging to the American Museum of Natural History at the writer's disposal, his appreciative thanks are due and here rendered to his friend Dr. Dean, honorary curator of fossil fishes, as well as to his assistant, Mr. L. Hussakof.

Dinomylostoma Eastman.

Arthrodiran fishes exhibiting characters transitional between Mylostoma and Dinichthys. Tritoral palato-pterygoid dental plates adapted for crushing, but the opposing lower dentition very similar to that of Dinichthys, except that the functional margin is thickened into a broad, more or less smooth, and regularly concave grinding surface, contracting in front and elevated into a blunt symphysial beak. Vomerine teeth subtrihedral, slightly prehensile, and of a general Dinichthys-like aspect. Dorso-median with prominent inferior carina terminating in an excavated posterior process; other plates of the abdominal armor resembling those of typical Coccosteans, the external surface covered with fine vermiculating rugæ.

Dinomylostoma beecheri Eastman.

Plate **1**, Figs. 4, 5; Plate **2**, Figs. 13, 14, 16, 17; Plates **4**, **5**.
Amer. Journ. Sci. 1906, ser. 4, **21**, p. 137, Text-Fig. 2.

The specific characters of this form are included under the foregoing generic diagnosis. That which is regarded as the most distinctive

feature, and serves at the same time to emphasize the transitional nature of this genus, consists in the beak-like termination of the mandibles in front, together with their deeply concave and approximately even oral margin. The general contour of the mandible, apart from lateral thickening of the oral margin, is Dinichthys-like; but precisely this thickened condition imparts to it a certain Palaeomylus-like aspect. As regards functional adaptation, therefore, Dinichthys and Dinomylostoma are related to each other in much the same way as are Rhynchodus and Palaeomylus amongst Chimaeroids. Approach to Dinichthyid conditions is to be noted also in the slightly prehensile form of the vomerine teeth of Dinomylostoma. These teeth, if found in the detached condition, might readily be mistaken for the so-called "premaxillaries" of Dinichthys. On the other hand, the palato-pterygoid dental plates are typically Mylostomid. If they in their turn were known to us only in the detached condition, they would be unhesitatingly assigned to the genus Mylostoma. One perceives, accordingly, that the new form acquaints us with an interesting intermediate stage of modification between two well-marked types of Arthrodires, of which the Mylostomid is clearly the more primitive.

Our knowledge of the form *sub judice* is derived from a unique example, the history of which is as follows: Collected in the year 1868 from a shaly outcrop of Portage beds upon the farm of John Pierce, near Mt. Morris, New York, it was acquired by the late Prof. O. C. Marsh, and by him deposited in the Yale Museum. Here it remained for many years stored away and apparently forgotten. The writer's attention was first called to it by his lamented friend Professor Beecher, shortly before the unfortunate loss to science of the latter. Through the kindness of his successor, Prof. Charles Schuchert, the specimen was committed to the present writer for further preparation, study, and description, and for this privilege cordial thanks are here offered. At Professor Schuchert's suggestion, also, the specific title is inscribed to the memory of his distinguished friend and predecessor.

The type specimen upon which the species is founded presents the following parts for examination: nearly the complete dentition; fragmentary portions of the headshield; a part of the left suborbital shown in Fig. F; the dorso-median, substantially perfect; and two of the ventro-lateral plates, one complete, the other in impression.

Naturally, chief interest is engaged by the dentition. Both mandibles are preserved, and are shown from the external and internal aspects in Plates 4 and 5 respectively. The anterior margin rises into a

rather obtuse symphysial beak, but slightly elevated above the broad, flat, deeply excavated functional surface. The latter displays a single inconspicuous tubercle close to the external margin, situated about midway its length, and its posterior termination is marked by a still larger tubercle, rather elongate, and placed externally like the first. This posterior prominence fits snugly against the single large rounded boss of the opposing palato-pterygoid dental plate, the adjustment being such as to orient the hinder pair of upper dental plates with absolute precision. It is fortunate that we have this topographic control, since it serves as a check upon any theoretical reconstructions of the upper dental plates of Mylostoma that might be attempted.

The lower dental plate proper, or that portion of the mandible which

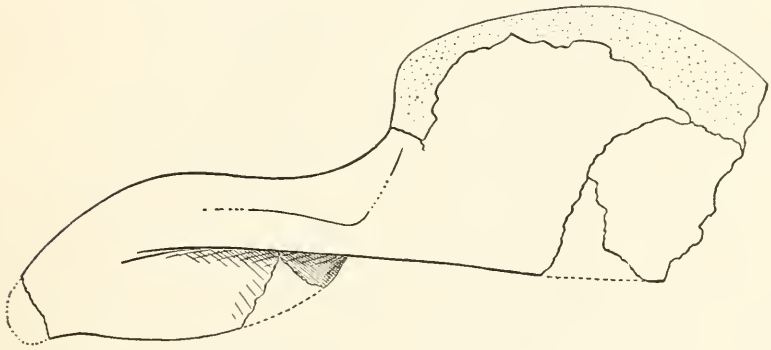


FIG. F. — Portion of left suborbital of *Dinomylostoma beecheri* Eastman, from the Portage of Mt. Morris, N. Y. External aspect, × ½.

corresponds to the lower dental plate in related forms, is so intimately united with the supporting splenial that the two might be said, so far as appearances go, to form an integral piece. The same, however, might be said of modern Dipneumon genera, and if one is really in doubt whether two separate entities are concerned, that doubt is dispelled by the most cursory examination of the mandible in Mylostoma, where we find a veritable pharos for indicating Dipnoan affinities. The splenial of Dinomylostoma is developed as a long, slender posteriorly rounded shaft, much resembling that of Dinichthys, but relatively a little deeper. A fact of great interest is that both of these elements, the right and the left, are preserved in natural association with the articular cartilage, and this, although considerably compressed by mechanical processes, is seen to form a hinge for attachment with the suspensorial cartilage of

the cranium (Fig. G). The cartilage extends along the outer side only, as we should expect it to, of the splenial, for a distance equalling at least the depth of the bone it is attached to. Originally it may have extended for an even greater distance anteriorly, but in the actual condition of the specimen this cannot be determined positively. The usual groove which is presumed to have been occupied by a remnant of

FIG. G. — *Dinomylostoma beecheri* Eastman. Calcified articular cartilage belonging to type specimen, detached from outer face of right mandibular ramus; found in position corresponding to that shown in Plate 4, Fig. 23.

Meckel's cartilage is present along the inferior margin, its direction and position being as in Dinichthys and other Coccosteans.

Both of the vomerine teeth are present, and are readily identifiable as such on account of their strong resemblance to the corresponding elements of Dinichthys. Their extreme tips are broken away, but it is evident from the cross-section of the fractured part, as seen from the oral surface (Plate 1, Figs. 4, 5; Plate 2, Figs. 13, 14), that they must have been prehensile to about the same degree as the symphysial beaks

of the lower jaw, against which they closed. Their posterior face is smooth and slightly concave, as if for co-adaptation with the front margin of the anterior pair of palato-pterygoid dental plates. These latter are unfortunately missing in the type specimen, but as their allotted space is accurately demarcated on all sides, it is easy to restore their outlines. Thus, their posterior face must have abutted directly against the hinder pair of palato-pterygoids, and their outer face have been conformable to the external margin of the opposing lower dental plates; this much, at least, is certain. The inner face we should expect to be linear and elongate, as in Mylostoma, in consequence of the close juxtaposition of the two forward plates along the median line. That the corresponding plates of Mylostoma were arranged in the manner indicated is too evident to require demonstration; it must be apparent to any one who has ever handled the actual specimens, and applied their oral surfaces against the lower dentition.

The hinder pair of palato-pterygoid dental plates is excellently preserved, as will be seen from the illustrations given in Plate 2, Figures 16 and 17. These plates are elongate, of irregularly cruciform outline, moderately thick, and develop on their oral surface a single, large, rounded, centrally placed tubercle, which plays into a corresponding depression of the lower dentition in the manner already described. A peculiar feature of the plates in question is that the sinus which occurs in about the middle of the posterior face shows vertical flutings and is otherwise differentiated from the adjacent lateral edge of the plate. It is difficult to imagine what purpose this excavation with fluted walls could have served, unless it enclosed a passageway of some sort. The opening is much larger than is needful to conduct nerves or blood-vessels; and besides, it communicates directly with the mouth cavity, as is evident from the fact that the flutings are conterminous with both the upper and lower surfaces of the plate. Now the only openings of corresponding size and position that we are acquainted with in the palate of any other fishes are the *posterior nares*, which are found only in Dipnoans; and the inference is by no means remote that we have to do with these very structures in Dinomylostoma.

Figure H is intended to show the relative positions of upper and lower dental plates as determined for this genus, without, however, including the anterior pair of palato-pterygoid elements. The vomerine teeth are shown from their oral aspect, and in their natural position with respect to each other, but removed further forward from where they belong for the purpose of displaying the contour of the mandibular

element. We will conclude our description of the new form by presenting measurements of the more important elements as follows:

The vomerine teeth have a length along their narrow longitudinal margin of 3 cm. Their width across the posterior face in a transverse direction is 3.5 cm., and obliquely across the external face it is 4 cm. The posterior palato-pterygoid dental plates have major and minor axes of

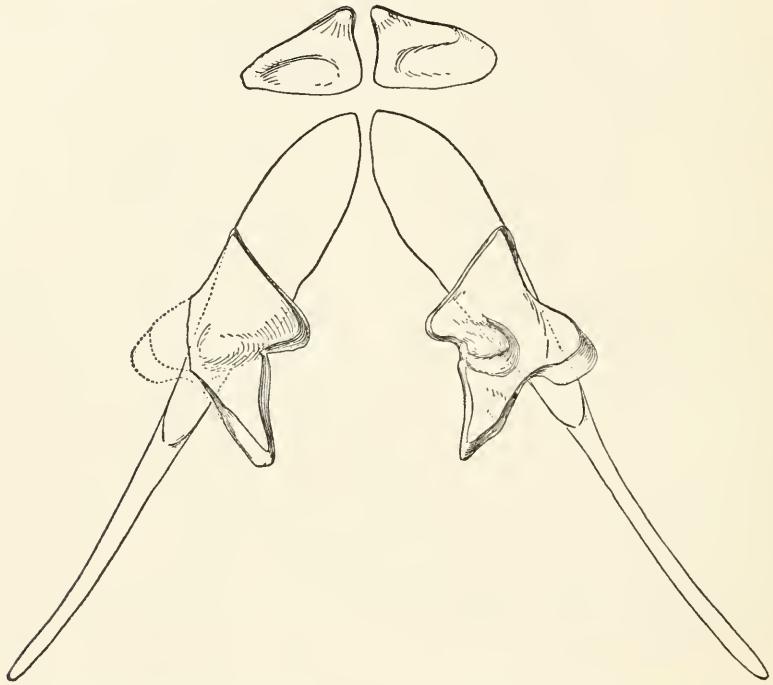


FIG. H. — Diagram showing contour of oral margin of mandibular and posterior palato-pterygoid dental plates of *Dinomylostoma beecheri* Eastman, in front of which are shown the upturned vomerine pair, all drawn to the same scale, and the members of each pair placed in natural position with respect to each other. × ½.

6.8 and 5 cm. respectively, and a thickness of about 2 cm. except in the central portion where the dome-shaped tubercle increases it to a total of 2.5 cm. The extreme length of the mandible falls a trifle short of 20 cm., that of the functional margin is about 8 cm., and the maximum width of the latter is 2.3 cm. The dorso-median plate, indistinguishable in form from that of *Dinichthys intermedius*, and with well developed posterior process, is estimated to have had a total width of 18 cm. It is unfortu-

nately not preserved for its entire length, but would seem to have been at least 15.5 cm. long, exclusive of its terminal process. The dimensions of the ventro-lateral plates cannot be determined with any great nicety, but although exhibiting about the same proportions, they are fully one-fifth smaller than the corresponding elements in the unique example of Mylostoma figured by Dean.

EXPLANATION OF PLATES.

PLATE 1.

Upper Dentition of Mylostomids.

All specimens are shown of the natural size. Those of Mylostoma are from the Cleveland shale (Upper Devonian) of Sheffield, Ohio.

Fig. 1. Right anterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Type specimen figured in Plate 13, Fig. 4 of Newberry's Monograph, 1889. Original preserved in American Museum of Natural History (Cat. No. 43 G).

Fig. 2. Left anterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Type specimen figured in Plate 15, Fig. 4 of Newberry's Monograph, 1889. Original preserved in the Museum of Comparative Zoölogy (Cat. No. 1435).

Fig. 3. Left anterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Type specimen figured in Plate 13, Fig. 3 of Newberry's Monograph, 1889. Original preserved in American Museum of Natural History (Cat. No. 42 G).

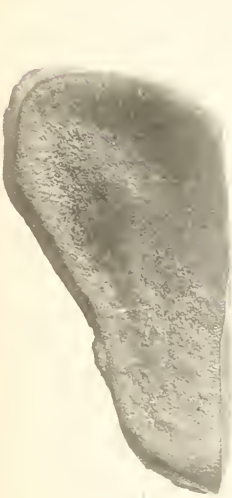
Figs. 4, 5. Right and left vomerine teeth of *Dinomylostoma beecheri* Eastman, seen from the anterior external aspect. Type in Peabody Museum, Yale University. From the Portage beds of Mt. Morris, N. Y.

Fig. 6. Left posterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. This plate belongs to the small, probably immature, individual described by Dean in the Memoirs N. Y. Acad. Sci. for 1901. Original preserved in the American Museum of Natural History; counterpart in the Museum of Comparative Zoölogy.

Fig. 7. Vomerine tooth of *Mylostoma variabile* Newb. Original in Museum of Comparative Zoölogy (Cat. No. 1439).

Fig. 8. Right posterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Original preserved in American Museum of Natural History (Cat. No. 3591).

Fig. 9. Left posterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Original preserved in the Museum of Comparative Zoölogy (Cat. No. 1437).



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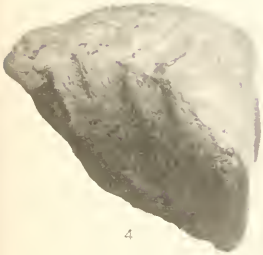

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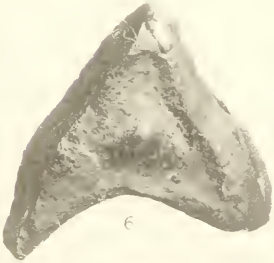

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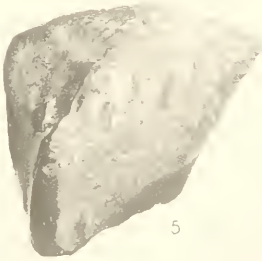

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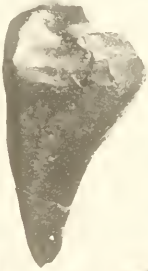

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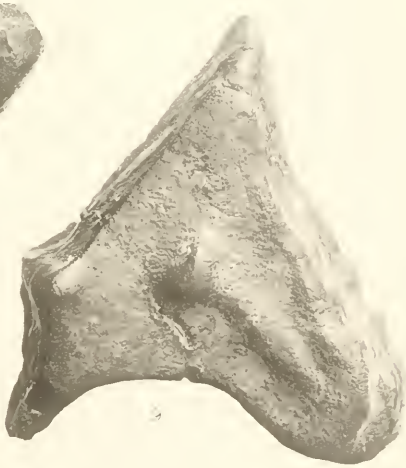

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PLATE 2.

Upper Dentition of Mylostomids.

Fig. 10. Left posterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Original preserved in American Museum of Natural History (Cat. No. 44 G).

Fig. 11. Same as preceding. Original preserved in the Museum of Comparative Zoölogy (Cat. No. 1438).

Fig. 12. Left anterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. Original preserved in American Museum of Natural History (Cat. No. 3290).

Figs. 13, 14. Vomerine teeth of *Dinomylostoma beecheri* Eastman, seen from the posterior aspect, and showing gently concave surface for co-adaptation with the anterior pair of palato-pterygoid elements. Originals in Peabody Museum, Yale University.

Fig. 15. Right posterior palato-pterygoid dental plate of *Mylostoma variabile* Newb. turned with the posterior margin uppermost, or in opposite position from Figs. 8, 9, 16 and 17. Type specimen figured in Plate 15, Fig. 5, of Newberry's Monograph, 1889. Original preserved in the Museum of Comparative Zoölogy (Cat. No. 1436).

Figs. 16, 17. Posterior pair of palato-pterygoid dental plates of *Dinomylostoma beecheri* Eastman, to be compared with Figs. 8 and 9 of Plate 1.

Fig. 18. Vomerine tooth of a small undetermined Coccostean, possibly of Dinichthys, shown for purpose of comparison with the vomerine teeth of Mylostoma.

All specimens are shown of the natural size, and with the exception of Figs. 13, 14, 16, and 17 are from the Cleveland shale (Upper Devonian) of Sheffield, Ohio.

PLATE 3.

Lower Dentition of Mylostoma.

Figs. 19, 20. Oral aspect of lower dental plates belonging to the left ramus of the mandible in *Mylostoma variabile* Newb. Both specimens are preserved in the Museum of Comparative Zoölogy (Cat. Nos. 1429, 1431) and have been previously figured in Plate 15 of Newberry's Monograph. Natural size.

Fig. 21. Oral aspect of left mandibular ramus of *Mylostoma terrelli* Newb. This is the type and only known example; it is preserved in the Museum of Comparative Zoölogy (Cat. No. 1430). × ¾.

PLATE 4.

Lower Dentition of Dinomylostoma.

Figs. 22, 23. External aspect of right and left mandibles of *Dinomylostoma beecheri* Eastman. Portage beds; Mt. Morris, New York. Original in the Peabody Museum of Yale University. Natural size.

PLATE 5.

Lower Dentition of Dinomylostoma.

Figs. 24, 25. Inner aspect of the mandibular rami belonging to the type specimen of *Dinomylostoma beecheri* Eastman. Natural size.

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FOSSIL HYMENOPTERA FROM FLORISSANT, COLORADO.

By T. D. A. Cockerell.

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June, 1906.

No. 2. — *Fossil Hymenoptera from Florissant, Colorado.*

By T. D. A. Cockerell

The Tertiary shales of Florissant, Colorado, have been made famous through the writings of Lesquereux and Scudder, wherein are described hundreds of species of plants and insects preserved in fine volcanic ash and sand. The vast multitudes of individuals and species, and the wonderful state of their preservation, render the locality perhaps the richest of its kind in the world, and afford us as good an opportunity as could be looked for to reconstruct the fauna and flora of a remote age. Just what age this is, is a matter in dispute; but for various reasons, which I give in a paper to be issued in the University of Colorado Studies, I think it is almost surely Miocene.

Unfortunately, Mr. Scudder has not been able to finish the investigation of the materials he secured at Florissant. In his work on *Tertiary Insects* (1890) he indicated briefly the great wealth of undescribed species. Since then he has published some miscellaneous species (Bull. **93**, U. S. Geol. Surv., 1892), the Rhynchophorous Coleoptera (Monog. U. S. Geol. Surv., 1893, **21**), the Adephagous and Clavicorn Coleoptera (Monog. U. S. Geol. Surv., 1900, **40**), and the Tipulidae (Proc. Amer. Philos. Soc., 1894, **32**). The great work accomplished by Mr. Scudder can in some measure be understood by one who has learned the difficulties of this kind of investigation; the eye-strain involved in determining minute and often nearly obliterated features, and the wide knowledge and good judgment necessary in order to classify specimens which only exhibit part of the characters commonly used as diagnostic. It is not to be expected that another such master of palaeoentomology will appear to take up the work; but the valuable materials must not be neglected, and we may hope that with the aid of several workers they will all be made known.

The present contribution deals with the bees and wasps, and one species of Stephanidae, kindly entrusted to me by the Museum of Comparative Zoölogy. In addition to the species described, I have examined more imperfect specimens of perhaps as many others; but it has seemed best to publish only those which could be classified with

some certainty, and adequately diagnosed. If the imperfect specimens just mentioned had been all the Hymenoptera found at Florissant, it would have seemed worth while to give them more careful scrutiny, and to describe a number as well as possible. No doubt, by very careful and prolonged comparisons, such portions of the venation as could be determined would be found in many cases to reveal probable or practically certain affinities; but the work would be arduous in the extreme, and would test one's skill to the utmost. As it is, the numerous well-preserved specimens give us an excellent idea of the fauna, and the determination of the poorer materials may be at least postponed without any serious injury to science.

In numerous cases, owing to the wings being folded, or one beneath another, the venation looks at first sight abnormal, and will appear to disagree with the descriptions offered. The future student of these insects should therefore not conclude too hastily that the descriptions are inaccurate.

In general terms, it may be said that the Florissant Hymenoptera do not differ greatly from their modern representatives. While some of the extinct genera are apparently more primitive than the *dominant* genera of the same groups to-day, they are scarcely more so than certain genera which still exist in the modern fauna. Thus, among the Scoliids, we naturally assume that those forms with regular venation, like that of many other wasps, are more primitive — at least in respect to this character — than those with broken or irregular cells. The two fossil genera of this group are therefore less specialized in venation than the common species of to-day, but they are in the same general stage of development as the rare American genus Engycystis, and the Australian Austratiphia. Thus, if it were possible to restore the Florissant Hymenoptera to their original state, and send them to some entomologist as coming from an out of the way region, he would see in them nothing transcending the possibilities of the modern world.

It must further be said, that the types represented do not suggest tropical or subtropical conditions; they accord well with the vegetation in indicating a climate like that of the austral zones of the temperate region. The bees are principally of genera found flying in Colorado to-day, and there is no indication of the types especially characteristic of Mexico. Both among the bees and the wasps, the element which we regard as of neotropical origin is conspicuously absent. It is only just to remark, with regard to the bees especially, that the generic identity assumed from the parts preserved might in some cases be belied, could we examine the

mouth-parts, etc. The evolution of the bees has gone on principally in the development of the mouth-structures, the venation remaining nearly as in the fossorial wasps, or at any rate not undergoing any radical changes. Hence it may be that if we could see the tongue, palpi, etc., of the Florissant species of Halictus, Andrena, Anthidium, etc., we should be compelled to remove them from those genera; but the agreement of the wings and general appearance is such that I feel as confident of the generic determinations as is possible under the circumstances.

The families represented are exactly those dominant to-day in North America, and the absence of certain groups must no doubt be regarded as accidental.

One would infer from the evidence afforded by the Florissant Hymenoptera, that the genera of this group are more persistent in time than the genera of Mammalia, but less so than those of flowering plants, especially trees. The same conclusions might be reached independently by a study of geographical distribution, at least so far as they relate to mammals and Hymenoptera. No doubt the genera of Hymenoptera are more widespread than some other groups of organisms which may possess greater antiquity, owing to the ready locomotion of the former.

Unfortunately, we have no series of mammals known to be of the same age as the Florissant shales. The White River beds, which Matthew (1899) calls Oligocene, have produced in Colorado some 63 species of mammals, all referred to extinct genera except a few pertaining to Didelphys and Sciurus. These animals, very differently from the Florissant Hymenoptera, if produced alive would excite the greatest amazement. Species of Titanotheriidae, Elotheriidae, Hyaenodontidae, Rhinocerotidae, Camelidae, Oreodontidae, etc., would cause bewilderment to a zoölogist to-day. Even those pertaining to families still inhabiting the earth would for the most part look quite strange to us, being of extinct genera.

The Loup Fork beds, referred to the Upper Miocene, have produced in Colorado about 28 species of mammals, but even these are nearly all of extinct genera, though only two, possibly three, of the families are extinct. We note the arrival of the Elephantidae, and the great abundance and variety of Equidae. As the Florissant shales are certainly not *later* than the Loup Fork, but doubtless earlier, the opinion that the families and genera of aculeate Hymenoptera are much more conservative than those of Mammalia seems justified. The same facts lead us to believe that the differences noted by Scudder between the insects of the Green River series and Florissant surely indicate a considerable difference

in time; and since the Florissant beds must for a variety of reasons be held to be the later of the two, the probability that they are Miocene is augmented.

APOIDEA.

TABLE OF SPECIES.

Three submarginal cells 1
Two submarginal cells 5

1. Basal nervure strongly curved; marginal cell ending in a point on costa; insect small, about 6½ mm. long, anterior wing somewhat over 4 mm. *Halictus florissantellus.*

Still smaller; length about 4½ mm., intense black *Halictus scudderiellus.*

Basal nervure not, or not strongly, curved; larger, anterior wing over 5 mm. long 2

2. Second s. m. receiving first r. n. *before* the middle; anterior wing about 8 mm. long . . . . . *Calyptapis florissantensis.*

Second s. m. receiving first r. n. *beyond* the middle, or at apex; anterior wing less than 7 mm. long 3

3. Point of marginal cell a short distance from costa; second r. n. bent near upper end; first s. m. shorter than second or third on cubital nervure *Lithandrena saxorum.*

Point of marginal cell a short distance from costa; second r. n. not bent near upper end; size small . . . . . *Ceratina disrupta.*

Point of marginal cell on costa; second r. n. not bent near upper end . . 4

4. Abdomen normal; second s. m. just three times as broad below as above *Andrena sepulta.*

Abdomen clavate; second s. m. narrower, not nearly three times as broad below as above . . . . . *Andrena* (?) *clavula.*

5. Stigma small; insect broad and robust 6

Stigma fairly or quite large; insect smaller, or less robust 8

6. Abdomen subglobose, without visible markings; second r. n. passing well (about 120 μ) beyond apex of second s. m.; breadth of marginal cell about 630 μ . . . . . *Dianthidium tertiarium.*

Abdomen longer, banded 7

7. Wings strongly infuscated; marginal cell about 720 μ broad *Anthidium scudderi.*

Wings clear; marginal cell about 570 μ broad . . . . *Anthidium exhumatum.*

8. T. m. with the lower end most apicad, so that it forms an angle with b. n.; eyes prominent . . . . . *Libellulapis antiquorum.*

T. m. with the lower end most basad so that it is in line with lower end of b. n. 9

9. Small, length slightly over 6 mm.; abdomen dark brown; width of marginal cell 255 μ . . . . . *Heriades halictinus.*

Larger, length 8 mm. or over; width of marginal cell 300 μ 10

10. Abdomen light reddish brown; head smaller . . . . . *Heriades laminarum.*

Abdomen banded; head larger . . . . . *Heriades bowditchi.*

The following abbreviations are used: b. n. = basal nervure; s. m. = submarginal cell; r. n. = recurrent nervure; t. m. = transverso-medial nervure; t. c. = transverso-cubital nervure. In the wing, breadth always means in the direction of the short axis in the case of the marginal cell and stigma.

CERATINIDAE.

Ceratina disrupta, sp. nov.

Black; probable length about 8 mm., or perhaps less; anterior wing about or not quite 6 mm., dusky, especially in marginal cell and beyond; head separated a short distance from body in type and seen in side view, about 2175 μ long and 1050 from back to front, with the broadly rounded cheeks and general appearance of Ceratina; stigma well-developed, its width about 150 (this and all following measurements in μ), its margin bordering marginal cell about 300; marginal cell 1350 long, 370 wide, ending in a point a little away from costa; first s. m. 800 long, its length on cubital nervure 525; second s. m. much narrowed above its length on marginal 200, on cubital nervure 600; third s. m. 300 long on marginal, nearly 600 on cubital; lower section of b. n. (bordering first discoidal) gently, not strongly, curved, about 675 long; length of first discoidal 1500; first r. n. entering second s. m. beyond middle; second r. n. entering third s. m. 150 from its end, the upper end of the nervure not bent.

Type. — No. 2001, Mus. Comp. Zoöl. Florissant, Col. (No. 9355, S. H. Scudder Coll.).

MEGACHILIDAE.

Anthidium Fabricius.

The species of *Anthidium* differ among themselves in the details of the venation, as shown in the following table:

First r. n. meeting first t. c., or passing a very short distance beyond it.
A. oblongatum Latr. (Europe).
A. bernardinum Ckll. (So. Calif.).
A. illustre Cress. (Western U. S.).

First r. n. passing a fair or long distance beyond first t. c. 1

1. B. n. meeting t. m.; t. m. of hind wing only moderately oblique
A. steloides Spin. (Chile).

B. n. passing basad of t. m. (sometimes very slightly); t. m. of hind wing very oblique 2

2. Basal angle of first s. m. about as acute as angle formed by basal and subcostal nervures . . . . . *A. laterale* Latr. (Palaearctic).

Basal angle of first s. m. obviously more obtuse than angle formed by basal and subcostal nervures . . . . *A. emarginatum* Say (Colorado, etc.).
A. conspicuum Cress. (Colorado, etc.).
A. scudderi, sp. nov. (Florissant).
A. exhumatum, sp. nov. (Florissant).

It thus appears that so far as the venation shows, the Florissant species are nearest to some of those flying in Colorado at the present day. In the following descriptions, those characters are italicized which may especially be relied upon for the separation of the fossil species.

Anthidium scudderi, sp. nov.

Robust, probably about 15 mm. long (the end of the abdomen is lacking); width of thorax about 5 mm. (probably increased by flattening), of head about $4\frac{1}{2}$; general appearance normal; head and thorax black, with faintly indicated light markings; apparently the clypeus was light, and a large patch on vertex, and a pair of longitudinal subdorsal stripes on anterior part of thorax (mesothorax), but these markings, vaguely indicated by reddish color, may not truly represent the tegumentary colors; mandibles apparently short and heavy; antennae and legs not visible; abdomen broad, very pale reddish, *with the hind margins of the segments infuscated*, the darkening strongest on the actual margin, and gradually fading anteriorly, the dark band occupying about a third of the visible part of the segment (much less on the first); on the second to fourth segments are rather poorly indicated dark marks in the subbasal region in the middle line, and on each extreme lateral margin, apparently indicating a subbasal band very broadly interrupted in the subdorsal region; it is perhaps probable that the abdomen was in life yellow marked with ferruginous; the apparent pattern is not quite like that of any modern species before me, but it is not difficult to see how it might become modified into some of the patterns seen in modern Rocky Mountain species. Quite a close general resemblance is shown by the abdominal pattern of *A. bernardinum*, but in that species the lateral subbasal dark spots are much nearer the middle line.

Anterior wings about 8 mm. long; *wings strongly infuscated*, except in the basal region, conspicuously hairy. Venation in general quite normal; *marginal cell broad*, its width about 720 μ; b. n. going only just basad of t. n.; first r. n. joining second s. m. a long distance (quite 420 μ) from base; discoidal nervure oblique and curved, so that *the second discoidal cell is conspicuously longer on lower than on upper side*, the upper outer corner being very obtusely rounded. Hind wing with t. m. long and very oblique.

Type. — No. 2002, Mus. Comp. Zoöl. Florissant, Col. (No. 11,381, S. H. Scudder Coll.). Dedicated to Mr. Scudder.

Anthidium exhumatum, sp. nov.

♂ Robust; length $13\frac{1}{2}$ mm.; width of head a little over 4, of thorax about 5, of abdomen about $5\frac{1}{2}$ mm., these measurements (particularly the last) no doubt increased by crushing; head and thorax black without any apparent markings; mesothorax coarsely roughened; ocelli large, not approaching eyes, distance between middle and lateral ocelli a little less than the diameter of one; abdomen with broad pale reddish bands, *the hind margins of the segments not darkened, nor any spots visible*; apex broadly rounded, no processes or teeth being visible, but a large quadrate area is occupied by the genitalia, the exact structure of which cannot be made out; hind tarsi apparently broad and flattened; hind tibiae with a rather abundant hairy scopa. *Wings colorless;* nervures pale; *marginal cell not so broad*

as in A. scudderi (its breadth about 570 μ); *stigma shorter and smaller*, more like that of Megachile; *second discoidal cell with the upper and lower sides about equal*, the upper apical corner hardly depressed; b. n. almost meeting t. m.; first r. n. passing some distance beyond first t. c.; second perhaps passing slightly beyond apex of second s. m.; second (morphologically third) t. c. strongly bent near the middle; t. m. of hind wing hard to see but oblique.

Type.—No. 2003, Mus. Comp. Zoöl. Florissant, Col. (No. 13,709, S. H. Scudder Coll.) and reverse of the same specimen (No. 11,388, S. H. Scudder Coll.).

This is not quite so typical an Anthidium as *A. scudderi*, but I think it cannot be referred to any other genus. These bees are referred to Anthidium and not to Megachile, not only because of the color of the abdomen, but also on account of the characters of the venation. The following comparison shows the difference in venation between *A. scudderi* and *Megachile calogaster*:

A. SCUDDERI.	M. CALOGASTER.
B. n. goes a little basad of t. m.	B. n. falls a little short of t. m.
First r. n. joins second s. m. at a distance from its base almost as great as half length of r. n.	First r. n. joins second s. m. at a distance from its base not greater than one quarter length of r. n.
Stigma larger and more pointed.	Stigma small and truncate.
Marginal cell conspicuously broader than greatest breadth of first s. m.	Marginal cell conspicuously narrower than greatest breadth of first s. m.
First discoidal much broader.	First discoidal long and narrow.
Second r. n. not well seen, but enters second s. m. at or very near tip.	Second r. n. enters second s. m. about as far from apex as first r. n. does from base.
T. m. of hind wing very oblique.	T. m. of hind wing not or hardly oblique.

Specimen No. 8444 is an Anthidium exactly agreeing with *A. exhumatum* in the width of the marginal cell and in the shape of the second discoidal, but having most of the venation obliterated. It differs by the strongly banded abdomen (suggestive of the living *A. occidentale*), which, however, is not spotted. It appears to be a female, and I little doubt that it represents that sex of *A. exhumatum*.

Dianthidium tertiarium, sp. nov.

♂ Body black or dark brown, without visible markings; head lacking; length, exclusive of head, about 8 mm.; width of thorax about 4⅜, of abdomen about 4½ mm.; anterior wing about 9 mm. long, slightly dusky, with the nervures dark; abdomen subglobose, terminating in two rather small and obscure tubercles, which are about as far distant as the breadth of the basal joint of hind tarsus at apex; posterior claws with a strong inner tooth. Venation of anterior wings normal; first r. n. ending about 300 μ from base of second s. m.; second r. n. passing about

120 μ beyond apex of second s. m.; marginal cell about 630 μ broad; first s. m. narrower than in *Anthidium exhumatum*; t. m. obliterated.

The general shape and the structure of apex of abdomen seem to indicate a species of the subgenus Anthidiellum, allied to the modern *D. gilense* Ckll. The venation agrees well with *D. gilense*, except that the first r. n. enters the second s. m. at a greater distance from the base and the marginal cell is more evenly rounded at apex.

Type. — No. 2004, Mus. Comp. Zoöl. Florissant, Col. (No. 806, S. H. Scudder Coll.).

Heriades laminarum, sp. nov.

Length 8 mm., robust, head and thorax black, abdomen very light reddish brown, doubtless red in life; width of abdomen 3 mm.; length of anterior wing about 4½ mm., venation pale reddish-brown; stigma fairly large, vein separating first s. m. from marginal cell; not quite as long as that separating stigma from marginal cell; marginal cell narrow and long, its width 300 μ, its apex rounded; first discoidal about 225 μ shorter than marginal; first s. m., on cubital nervure, about 675 μ long, r. n. about but its total length is about 810; second s. m. about 645 long, receiving first r. n. about 100 μ from base, and second r. n. hardly 30 from apex; b. n. bent, falling a little short of t. m.; t. m. in a line with lower part of b. n. (which shows that the bee is not a Panurgid); third discoidal shorter than in *H. truncorum*. T. m. of hind wing not at all oblique.

Type. — No. 2005, Mus. Comp., Zoöl. Florissant, Col. (No. 3062, S. H. Scudder Coll.). This looks like *Proteriades semirubra* (*Heriades semirubra* Ckll.), but it appears to be allied to the ordinary species of Heriades.

Heriades halictinus, sp. nov.

♀ Length slightly over 6 mm.; anterior wing about 4 mm.; stout-bodied, head and thorax black, abdomen dark brown; eyes narrow. Stigma large; marginal cell about 975 μ long and 255 wide, end rounded; length of first s. m. on cubital nervure about 555; length of second s. m. about 510, it is not greatly narrowed above, its outer margin presents a gentle double curve; lower edge of first s. m. straight; upper apical corner of second discoidal rounded; lower section of b. n. curved as in Halictus, meeting t. m.; first r. n. joining second s. m. at a distance from its base equal to about half length of first t. c.; second r. n. joining cell at its extreme apex; length of lower (curved) part of b. n. about 300 μ.

Type. — No. 2006, Mus. Comp. Zoöl. Florissant, Col. (No. 10,564, S. H. Scudder Coll.).

At first sight one would take this for a small Halictus, but the t. m. and various other characters indicate its true affinity. Compared with *Halictus similis*, the principal differences in venation are as follows:

(1) Straight section of b. n. (bounding first s. m.) almost as long as curved section (only about a quarter as long in *H. similis*).
(2) Only two submarginal cells.
(3) Second r. n. joining second (morphologically third) s. m. at extreme apex (far from apex of third in *H. similis*).

(4) Second (morphologically third) t. c. strong (third weak in *H. similis*).
(5) B. n. meets t. m., which is curved in an opposite direction to b. n., its lower end oblique and more basad than the upper (less basad in *H. similis*).

The *H. similis* used for comparison is the form obtained by Mr. Lovell in Maine.

From *Heriades laminarum*, the present species is easily known by its darker abdomen and smaller size, as shown especially in the wing-measurements.

Heriades bowditchi, sp. nov.

No. 13,761 is larger (length, with the head thrust forward, 10 mm.); the thorax was evidently very coarsely punctate, the punctures contiguous; the following measurements are in μ; curved portion of b. n., 300; straight portion a little longer; width of marginal cell, 300; its length, about 1350. The t. m. is as in the other species. Head large, slightly wider than thorax; abdomen light-colored, with the apex brown (doubtless black in life), and two broad entire brown bands on the apical half. The anterior wing (not perfectly preserved) must have been a trifle over 5 mm. long. This differs from *H. laminarum* by the very decidedly larger head, and the banded abdomen. The apex of the marginal cell, seen from one direction, seems to be very obliquely truncate, but this may be illusory. The stigma is pale, but it is certainly much longer, and more slender than in *H. laminarum*.

A second example (No. 13,436, S. H. Scudder Coll.) confirms the validity of this species. The specimen is clearly a ♀.

The abdomen has broad entire reddish-brown bands on the first four segments, that on the first being faint; the marginal cell is pointed at tip, not obliquely truncate; its length, measured in this specimen, is the same as in the type. The t. m. curves inwards below, as in the type. The legs are hairy.

Type. — No. 2007, Mus. Comp. Zoöl. Florissant, Col. (No. 13,761, S. H. Scudder Coll.). Named after Mr. F. C. Bowditch, Mr. Scudder's companion at Florissant.

ANTHOPHORIDAE.

Calyptapis, gen. nov.

Stigma small but rather broad, about like that of Melissodes, the part within the marginal cell smaller than that without; marginal cell large and broad, the tip away from costa, obtusely rounded, not at all appendiculate; three submarginal cells, *the third very long, and considerably the longest*, narrowed a little more than half to marginal; the third t. c. with a very distinct double curve, *but not abruptly bent*, the cell (third s. m.) slightly appendiculate at its apical point, which is not far from the point of junction of the second r. n., the latter joining at the end of the straight lower margin, at the beginning of the upward curve, about as in *Melissodes atripes; second s. m. pentagonal*, the lower inner corner produced to considerably less than a right angle; the cell is rather large, broader below than high, narrowing above,

from the obliquity of the first t. c.; *it receives first r. n. before the middle,* at a point almost beneath the upper insertion of the first t. c.; first s. m. longer and larger than second, but not very greatly so, its lower margin gently curved, giving it a considerable breadth; b. n. straight, except near the basad end, where it bends downwards, *and is attached a short distance basad of the t. m.;* t. m. not oblique; second r. n. gently curved outwards, *its junction with the third s. m. forming an angle greater than a right angle;* second discoidal cell longer below than above, but not very greatly; *first discoidal not so long as marginal, but not greatly shorter.* The structural characters of the body cannot be ascertained.

Calyptapis florissantensis, sp. nov.

Black; anterior wing 8 mm. long, venation distinct, brown. The following measurements are in μ: width of marginal cell, 630; length of t. m., 300; width of second discoidal cell at apex, 825; from insertion of second r. n. to appendix at end of third s. m., 135; distance between insertion of first r. n. and base of second s. m., 375; length of b. n. about 1875.

Type. — 2008, Mus. Com. Zoöl. Florissant, Col. (No. 4933, S. H. Scudder Coll.).

So far as the venation goes, this genus is not far from certain species of the modern Melissodes. If it were a living insect, differing from Melissodes only in the manner indicated, it might be held to typify only a subgeneric group; but under the circumstances, and with a probability that the mouth-parts, etc., if preserved, would afford additional characters, it seems best to treat it as a distinct genus. It is probably too much to hope that fossil Anthophoridae will ever be found, showing adequately the palpi and other minute characters so useful in segregating modern genera.

ANDRENIDAE.

Libellulapis, gen. nov.

♀ Eyes apparently very prominent, the anterior part of face produced; first s. m. not so long; second discoidal narrower at end; second r. n. curved or bent outwards (straight in Parandrena); size small, abdomen conspicuously banded. The head, as preserved, has a singular resemblance to that of a dragonfly.

Libellulapis antiquorum, sp. nov.

♀ Length about 6 mm.; anterior wing about 5 mm.; width of thorax about $2\frac{1}{3}$, of abdomen about 2 mm. Head and thorax black; eyes prominent; flagellum stout; abdomen colorless, with a large brown patch on each side of middle of third segment; segments 4 and 5 each with a very broad entire brown band; 6 with a fainter band; middle and hind femora stout; venation brown; stigma large, but rather slender, with a large part in marginal cell, width of stigma about 195 μ (all the following measurements are in μ); marginal cell long and narrow, the tip on costa, width of cell about 300; b. n. practically straight, except a slight bend at proximal end, meeting t. m., which is oblique, at least 45° out of the straight line

with b. n.; first s. m. on cubital nervure about 630 long, its lower edge straight (which distinguishes it from Halictoides); second the same length, but only 360 long on marginal, the second t. c. with a double curve; first r. n. entering second s. m. about 150 from base, second about 60 from apex; breadth of second discoidal at base 195, at apex about 390. Compared with *Halictoides maurus* it differs by the second s. m. being much broader above, and receiving the second r. n. nearer its end, by the larger and narrower second discoidal, and the lower edge of first s. m. practically straight. Compared with *Hesperapis rhodoceratus*, the insertion of the recurrent nervures is different, and the second r. n. in particular is quite different in its direction, etc.; the straight lower edge of first s. m. agrees. Compared with *Parandrena andrenoides*, the stigma is smaller, and the second discoidal is not so broad apically. It does not agree with Diandrena or Biareolina.

Type. — No. 2009, Mus. Comp. Zoöl. Florissant, Col. (No. 9061, S. H. Scudder Coll.).

A second example (No. 8560, S. H. Scudder Coll.) shows that the legs are dark and hairy; the mandibles bidentate, the inner tooth rounded and small; flagellum about 195 μ broad; abdominal bands not well preserved, but a dark patch at apex. This example shows the same curiously prominent eyes as the type, hence it does not seem likely that the feature can be due in some accident of crushing. The eyes stand out on each side of the head to an extent of at least 300 μ, forming an angle with the anterior part of the face, which appears quadrate, twice as broad as long. The eyes of Parandrena are prominent, especially in the male, but they do not look like those of Libellulapis.

Halictus florissantellus, sp. nov.

♀ Length about 6½ mm.; stout-bodied; head, thorax, abdomen, and legs black; width of thorax 2 mm., of abdomen slightly more; length of anterior wing somewhat over 4 mm., stigma and nervures dark; middle tibia very much broader than basal joint of its tarsus (breadth of tibia 263 μ, of basal joint of tarsus 120); b. n. strongly curved, normal for Halictus, curved part 465 μ long, straight (upper) part about 150; t. m. a little oblique, a little basad of b. n., but not separated from it by an interval, its lower end more apicad, as is normal for Halictus; width of second discoidal at base 225; stigma large, about 165 μ broad; marginal cell about 270 broad, ending in a point on costa; wings quite hairy in costal region anterior to stigma; first r. n. joining cubital nervure 690 μ from base; submarginal cells not traceable.

Type. — No. 2010, Mus. Comp. Zoöl. Florissant, Col. (No. 921, S. H. Scudder Coll.).

Although only part of the venation is preserved, this, and the general appearance of the insect, agree with Halictus, and the generic reference seems safe.

Halictus scudderiellus, sp. nov.

♀ Length about 4½ mm., anterior wing about 2¾; intense black, including legs except tarsi, which are pale reddish; antennae stout, breadth of flagellum about

150 μ; legs normal, breadth of hind tibiae about 255 μ, of the basal joint of their tarsi about 150; dorso-ventral diameter of abdomen about 1350 μ, length of head about the same; costa somewhat arched; stigma large and black; marginal cell about 900 μ long and 195 wide, ending in a point on costa; first section of b. n. about 150 μ long; second section curved, fully 375 μ long; second s. m. on marginal a little over 150 μ long, on cubital nervure slightly over 300, the second t. c. curved outwards.

Type. — No. 2011, Mus. Comp. Zoöl. Florissant, Col. (No. 1966, S. H. Scudder Coll.).

Lithandrena, gen. nov.

A genus of Andreninae, allied to Andrena. It differs from Andrena and Nomia in the second r. n., which is strongly bent in its upper part, straight but oblique below; from Andrena it differs in the proportions of the submarginal cells (see the dimensions given below); and from Nomia by the tip of the marginal cell, which is pointed, and a little away from costa. The general appearance is that of an Andrena, but it cannot be referred to that or any other genus known to me. In Cresson's table it seems to run to Ceratina, but it is not allied to that genus.

Lithandrena saxorum, sp. nov.

♀ Length 8⅝ mm., anterior wing about 5⅓; diameter of thorax 3, head the same, of abdomen 3½ mm.; head and thorax black; abdomen light, with a broad entire dark band on each segment; legs hairy; flagellum rather stout, diameter 195 μ. In the following account of the anterior wing the measurements are in μ: stigma well-developed, diameter 175, length of the part within marginal cell 360; marginal cell long and pointed, length 1620, breadth 405, apex pointed, away from costa, but distance from apex to opposite point on costa scarcely 65; three submarginal cells; total length of first s. m. 900, but its length on cubital nervure only 570, the first t. c. being remarkably oblique, and having its lower part curved; length of second s. m. on cubital nervure 615, but it is greatly narrowed above, its length on marginal being only 150; first r. n. joining second s. m. 90 from end; length of third s. m. about 675, but it is greatly narrowed to marginal, its length above being about 270; second r. n. with a strong bend at the end of the upper two fifths, the lower three fifths straight; length of first discoidal cell 1650; b. n. meeting t. m.; lower section of b. n. slightly curved (but not more so than in some forms of Andrena), and more than twice as long as upper one (length of lower section 630, of upper 300); t. m. oblique, its lower end more apicad (as in Andrenines, Panurgids, etc.)

Type. — No. 2012, Mus. Com. Zoöl. Florissant, Col. (No. 8219, S. H. Scudder Coll.).

Andrena sepulta, sp. nov.

♀. Length 9 mm.; width of thorax 2½ mm., of head and abdomen about the same; abdomen of normal shape; flagellum stout; there is an appearance as if the eyes nearly met on the vertex, but I think this is illusory, resulting from the

way the head is crushed; head and thorax black; abdomen nearly colorless, with broad suffused reddish-brown bands on apical margins of the first three segments, the apex also dark; abdomen hairy all over; legs light reddish-brown, hind tibia about 1⅝ mm. long, tarsi hairy; wings very hairy. The following wing-measurements are all in μ: stigma large, pointed apically, width about 300, part within marginal cell about 450 long; marginal cell long and pointed, the apex on costa, length of cell 1605, breadth 375; three submarginals, first and third long, second short, much narrowed above, almost triangular, third much narrowed above; first s. m. on cubital nervure 810, its total length 1125; second s. m. on cubital n., 405, on marginal, 135; third s. m. on cubital n., 720, on marginal, 330; bend of third t. c. about 210 from cubital n.; first r. n. enters second s. m. at extreme apex, second enters third s. m. about 90 from apex; second r. n. leaves cubital n. at a right angle, but gently curves inwards, being nowhere at all bent; upper section of b. n. 330; lower section 630; lower section gently curved, but not at all as in the Halictines; b. n. falling about 60 short of t. m., which is oblique, its lower end more apicad.

Type. — No. 2013, Mus. Comp. Zoöl. Florissant, Col. (No. 14,288, S. H. Scudder Coll.). The venation is not exactly like that of any modern species with which I have compared it, but the differences are unimportant.

Andrena (?) clavula, sp. nov.

♀. Length 8. mm.; width of thorax 3, of head 2; length of anterior wing 6⅝ mm.; eyes ordinary; flagellum stout, subclavate, rather short, about 300 μ broad near end; head and thorax black, femora dark; hind tibiae and tarsi apparently pale, but middle tibiae dark; wings somewhat dusky; abdomen subclavate, dark reddish-brown, with three rather narrow pale bands, occupying hind margins of segments 2 to 4 and the extreme bases of the adjacent segments.

Venation (front wings) as in *A. sepulta*, except that second s. m. is narrower and more parallel-sided. Measurements in μ: width of stigma 240; length of marginal cell about 1455, its width 360; lower section of b. n., 630; second s. m. on cubital n., 360, on marginal, 155.

Type. — No. 2014, Mus. Comp. Zoöl. Florissant, Col. (No. 6963, S. H. Scudder Coll.). The shape of the abdomen is like that of a ♀ Ceratina, or possibly certain Halictines, but the venation does not agree with these. As the venation is exactly the same (speaking generically) as that of *A. sepulta*, it seems that the insect should be considered congeneric.

SPHECOIDEA.

CRABRONIDAE.

Tracheliodes mortuellus, sp. nov.

Black; length 7 mm. or somewhat more; abdomen petiolate; wings short; metathorax coarsely striate or ridged; upper posterior part of pleura finely striatulate; ocelli large, in a fairly high but not nearly equilateral triangle; mandibles stout, bent inwards apically (*i. e.* the outer edge becoming very convex), with the

cutting edge sinuate, but not distinctly bidentate; venation nearly as Kohl figures for *Tracheliodes megerlei* (*Brachymerus megerlei* Dahlb.), but having the stigma longer and narrower; the cells are practically the same; the costal cell is almost obsolete. Measurements in μ: length of marginal cell, 705; its breadth, 225; its breadth at the truncate end, 135; length of stigma, 420; its breadth, 105; length of s. m., 750; length of first discoidal cell, also 750; length of second discoidal, 540; r. n. joining s. m. at middle; t. m. a short distance basad of b. n.

Type. — No. 2015, Mus. Comp. Zoöl. Florissant, Col. (No. 3200, S. H. Scudder Coll.). I use the name proposed by Morawitz (1866) for this genus, because Brachymerus Dahlbom, 1845, though earlier, is a homonym. The genus has not hitherto been recognized in America, and it may be that if all the parts (*e. g.* of the mouth, etc.) of the extinct form could be examined, it would be found generically separable. At present, however, I can find no grounds for separation.

PEMPHREDONIDAE.

Passaloecus scudderi, sp. nov.

Length 6½ mm.; black, with a large, broad (width about 2½ mm.) head, globose thorax, and narrow sessile abdomen; breadth of thorax 2¾, of abdomen about 1½ mm., hind margins of abdominal segments broadly rather pale brown; ocelli normal; anterior wing about 3½ mm. long, venation rather pale brown; stigma rather large, about 135 μ broad; marginal cell normal; first s. m. about 780 μ long; second s. m. 255 long and about 375 high, its sides parallel; b. n. strongly curved; first r. n. entering first s. m. about 135 μ from its end; second r. n. joining second s. m. very slightly beyond the middle; apical corner of first discoidal rather more elongated and pointed than usual; b. n. falling a little short of t. m.; second discoidal oblique, slanting downwards apicad.

Type. — No. 2016, Mus. Comp. Zoöl. Florissant, Col. (No. 8758, S. H. Scudder Coll.). Closely allied to existing United States species.

PHILANTHIDAE.

Prophilanthus, gen. nov.

Large and robust, with a sessile abdomen; stigma little developed; marginal cell narrowly but very obtusely rounded at apex, the apical point away from costa, and quite without an appendix; third submarginal cell very broad, and equally broad above and below; basal nervure joining subcostal a long way basad of stigma. Compared with *Philanthus albifrons* Cresson, the fossil insect showed the following differences: —

(1) Portion of stigma in marginal cell shorter.

(2) Marginal cell bulging basally, *i. e.*, in the direction of the first t. c.

(3) Marginal cell with apex rounded, the apical point not on costa.

(4) Third t. c. arched, with more or less of a double curve (a character of Philoponus).

(5) Second s. m. broader, and receiving first r. n. more distinctly before middle.

(6) Third s. m. very much broader above, being equally broad (1050 μ) above and below.

(7) Prothorax, mesothorax, and metathorax longitudinally striate, especially the prothorax. (Very faint striation of the prothorax is visible in *P. albifrons.*)

Other characters are: width of third discoidal at base somewhat less than greatest width of first discoidal; first t. c. not angulated at basal third; second discoidal cell more than twice as long as its width at apex; cubital nervure not bent, but slightly curved downwards, at end of first discoidal; lower section of b. n. (bordering first discoidal) about twice as long as upper.

Prophilanthus destructus, sp. nov.

Length about 20 mm., robust, with a thick sessile abdomen, which appears to have had very broad black bands alternating with narrower yellow ones; antennae 6 mm. long, ordinary, the scape thick, flagellum black; length of anterior wing 12½ mm.; costa, up to base of marginal cell, broadly and very deeply infuscated, apex also clouded; marginal cell 3 mm. long, only just surpassing apex of third s. m.; first s. m. 3 mm. long; second and third submarginal cells combined, on cubital nervure, 3 mm. long; first discoidal cell 4½ mm. long, or nearly; second r. n. nearly straight, slightly bowed outwards; second s. m. very broad below; origin of first t. c. to insertion of first r. n., 450 μ; insertion of first r. n. to origin of second t. c., 975 μ; origin of second t. c. to insertion of second r. n., less than 150 μ.

Type. — No. 2017, Mus. Comp. Zoöl. Florissant, Col. (No. 7762, S. H. Scudder Coll.).

NYSSONIDAE.

Hoplisidia, gen. nov.

Size rather large; thorax hairy, the hairs long and quite simple; abdomen subcylindrical, broadest at the apex of second segment; first segment comparatively small, but not petiolate; apex pointed; the form of the insect like Gorytes or Hoplisus; stigma very narrow, almost obsolete; three submarginal cells, the first at least as long as the other two combined, the b. n. joining subcostal very far basad of the stigma; second s. m. broad, receiving the recurrent nervures near the end of the first and second thirds, the second r. n. curved and bent backwards to its point of insertion; third s. m. about twice as broad below as above; marginal cell narrowly rounded at apex; first discoidal conspicuously longer than marginal; b. n. sharply bent at origin of cubital; b. n. meeting t. m., or practically so; hind wings with cubital nervure exactly meeting t. m., which goes downwards for a short distance, and is then bent, finishing its course very obliquely. Among the Gorytinae, this falls closest to Hoplisus by the venation of the hind wings. It is peculiar for the very long first s. m., the b. n. meeting t. m., the reduced stigma, and the long first discoidal, the whole combination seeming to exclude it from the modern genera. The upper apical corner of the second discoidal is obtuse, as in *Gorytes mystaceus,* not acute as in *G.* (*Hoplisus*) *quadrifasciatus.* The second t. c. is much less oblique than in either of the species just cited, being very nearly vertical, and not at all parallel with the third t. c.

Hoplisidia kohliana, sp. nov.

Length (but in a somewhat disintegrated condition) about 20 mm.; anterior wings about 11½ mm., with a dusky cloud in the second s. m., and suffusedly below; length of abdomen about 10 mm., its width 4; measurements in μ: — length of marginal cell about 2250; its breadth 525; length of first s. m. about 2475; length of second s. m. on marginal, about 600; on cubital nervure about 1050; of third s. m. on marginal 600, and on cubital 1140; insertion of first r. n. from first t. c. 420; insertion of second r. n. from second t. c., 300; length of first discoidal, 3300.

Type. — No. 2018, Mus. Comp. Zoöl. Florissant, Col. (No. 742, S. H. Scudder Coll.). Named after the author of the most useful work on the genera of fossorial wasps.

Hoplisus sepultus, sp. nov.

Probable length about 10 mm. (head, much of thorax, and base of wings missing in the type); abdomen sessile, apparently normal, curved downwards as though in the act of stinging; hind tibia with tarsus about 4½ mm.; wings with a dark cloud in base of marginal cell, filling second s. m., and extending suffusedly below, still showing brilliant iridescent colors, especially in second s. m.; nervures more slender than in *Hoplisidia kohliana;* stigma large, its breadth about 170 (this and all following measurements in μ); marginal cell about 1500 long and 300 broad, pointed on costa; b. n. beginning at or very near base of stigma, and going a little basad of t. m.; length of first s. m. about 1275; second s. m. hexagonal, its length on marginal 300, on oblique apex of first discoidal 170 to 270 (this variation in the opposite wings of the same individual); first recurrent nervure to second (both received by second s. m.) 300; second r. n. to origin of second t. c. 150; third s. m. oblique, its greatest length (from upper basal to lower apical corners) 1125, its length on marginal 450, its length on cubital nervure 750, its tip surpassing marginal cell a little; insertion of third t. c. to tip of marginal cell 570; length of first discoidal about 2100; second r. n. very strongly bowed outwards. Hind wing reversed in the specimen; cubital nervure meeting t. m.; distance from t. m. to t. c. 1800.

Type. — No. 2019, Mus. Comp. Zoöl. Florissant, Col. (No. 980, S. H. Scudder Coll.).

No. 2710, S. H. Scudder Coll., is a wing of *Hoplisus sepultus*, with a small portion of the body. The measurements are in part greater than in the type indicating perhaps the opposite sex or a larger individual, but evidently not another species. Length of marginal cell about 1500, its breadth about 300; length of first submarginal about 1350, the b. n. hardly going so near stigma as in type; second s. m. on marginal 240; distance between first and second recurrent nervures at insertion 300; length of first r. n. 750 (same in type); insertion of second r. n. to origin of second t. c. 150; greatest length of third s. m. about 1200; third s. m. on marginal 570; length of third t. c. 795; insertion of third t. c. to apex of marginal cell 600. Cloud in second s. m., etc., as in type.

SPHECIDAE.

Ammophila antiquella, sp. nov.

Head and thorax black; abdomen all light; hind legs apparently light, with the tarsi black, in strong contrast; form slender. Length 12 mm.; abdomen 7⅛ mm., of which 3 mm. is petiole; width of thorax between wings 1⅝ mm., of head perhaps a trifle less; hind tibia 2¾ mm.; scape rather stout, as usual in the genus, metathorax transversely striated; wings not preserved. Anteriorly to the transversely striate area on thorax, some longitudinal striae can be seen. The petiole of abdomen is two jointed, the first joint scarcely over one third the length of the second; the breadth of the apical part of the abdomen is 1½ mm.

Type. — No. 2020, Mus. Comp. Zoöl. Florissant, Col. (No. 5974, S. H. Scudder Coll.). The specimen is poorly preserved, but as its relationships are evident, it is described.

VESPOIDEA.

SCOLIIDAE.

I here use this family name in a rather broad sense, including the Myzinidae and Tiphiidae of Ashmead. The two extinct genera here introduced are evidently related to the Tiphiid series, though not without features suggestive of the other groups. So far as I am able to judge, their affinity is closest with the rare and apparently primitive genus Engycystis Fox, found in Texas and Lower California. Curiously, however, a new genus from Australia is also related, and for purposes of comparison is herewith described. The following table separates the four genera from each other: —

Basal nervure entering subcostal at a distance from stigma much greater than length of stigma . . . . . *Austrotiphia*, gen. nov.

Basal nervure entering subcostal at a distance from stigma less than length of stigma 1

1. T. m. strongly oblique; stigma very narrow, not nearly filling the large stigmatic cell; marginal cell not surpassing third s. m. . . . . *Lithotiphia*, gen. nov.

   T. m. slightly oblique 2

2. Marginal cell surpassing third s. m., its apex rounded; costal cell large. *Geotiphia*, gen. nov.

   Third s. m. surpassing marginal cell; apex of marginal pointed, on costa; costal cell small or rudimentary . . . . . *Engycystis* Fox.

In Engycystis, the ventral constriction between the first and second abdominal segments is not nearly so marked as in Tiphia and Paratiphia, but in Austrotiphia the constriction is still less evident, being hardly appreciable. One would almost hesitate to place the latter genus in the Scoliids, were it not so obviously a Tiphiid in every other feature. The otherwise different Australian

genus Dimorphoptera Smith, appears to share the same character. Unfortunately this character cannot be determined in the fossil genera, owing to the position of the specimens.

♀ Having exactly the appearance of a Tiphia, but related to Engycystis, from which it differs thus: basal nervure joining subcostal much more remote from stigma; first s. m. long, broken by a false vein which passes from near the origin of the first t. c. to near the base of the stigma (the same is found in the Myzinid Plesia); marginal cell broadly rounded, — almost truncate, at apex; second s. m. extremely broad below, the first and second s. ms. exceedingly oblique; first discoidal cell at base narrower than first submarginal; t. m. very oblique (a character of the fossil Lithotiphia); hind wings with t. c. oblique (its upper end more basad), and cubital nervure ending about as far basad of upper end of t. m., as half the length of the latter. Stigma well-developed.

Austrotiphia kirbyi, sp. nov. ♀. Length about 13 mm., entirely black, looking like an ordinary Tiphia; eyes and mandibles as in Tiphia, simple; punctures nearly as usual in Tiphia; hind margin of prothorax straight, or rather gently concave, with no median lobe; anterior part of mesothorax smooth; scutellum shining, with very sparse and small punctures; parapsidal grooves very strong; tegulae small; abdomen with small punctures, closer and much smaller and more regular on basal part of segments; apical ventral plate not greatly surpassing dorsal; legs much as in Tiphia, but hind femora much broadened, sharply keeled below; hind tibiae short, with five or six rather broad teeth on outer edge; basal joint of hind tarsus tuberculate on outer side, not spined; middle and hind tibiae each with two white spurs; last joint of hind tarsi normal. Shoalhaven, Australia (W. W. Froggatt, 186). Captured in 1895, and now the property of the British Museum. Named after Mr. W. F. Kirby, in recognition of his work on Scoliidae.

In Geotiphia the teeth on the outer edge of the hind tibia are very broad, not spine-like as they are in Tiphia and Engycystis. In Austrotiphia they are comparatively broad and short, and the last one, in particular, recalls that of Geotiphia. In Tiphia the suture between the first two abdominal segments is evidently depressed at the sides, the abdomen being viewed from above; this is not the case in Austrotiphia. In this particular, so far as can be seen, Geotiphia and Lithotiphia resemble Austrotiphia. Geotiphia has some appearance of having had emarginate eyes, a character of the true Scoliids, but it is impossible to be sure about it. The spotted abdomen is also suggestive of the Scoliids, but not so the venation and the large stigma. When one uses the compound microscope to examine the eyes, the appearance of emargination disappears, and so far as can be seen, they look normal for the Tiphiidae. On the hind leg of the ♀, the tibial spurs are very short in Engycystis, very much less than half the length of the first tarsal joint; in Austrotiphia these spurs are very long, the longest (the hind one) being fully three quarters the length of the first tarsal joint; in the two fossil genera their character has not been determined. Tiphia has them long, like Austrotiphia. The second antennal joint in Austrotiphia is conspicuously smaller than in Tiphia. In Geotiphia the middle joints of flagellum are broader than long; in Austrotiphia (♀) they are about as long as broad;

in Tiphia (♀) they are conspicuously longer than broad. In Geotiphia and Tiphia the claws are bifid; in Austrotiphia they appear at first sight to be simple, because the inner tooth is flattened, shortened, and directed somewhat inwards. In Tiphia the middle coxae are very widely separated by a bilobed projection of the mesosternum; in Austrotiphia they are considerably closer together, the bilobed projection, although present, being much smaller. In Engycystis they are more as in Austrotiphia. In Tiphia the middle tibiae have only one spur, in Austrotiphia and Engycystis (as in the Myzinids) there are two. Tiphia has an open marginal cell and only two submarginals; Austrotiphia, Engycystis, Geotiphia, and Lithotiphia have a closed marginal and three submarginals.

Geotiphia, gen. nov. foxiana, sp. nov.

Length about 11½ mm.; black, with light markings on abdomen; femora black, tibiae and tarsi light, probably red in life; the abdominal markings, presumably yellow in life, consist of a broad transverse spot or patch on the first segment, rounded at sides and deeply emarginate posteriorly, a couple of transversely oval spots on second segment, and a pair of smaller and rounder ones on third; first segment broad, broadly rounded in front; width of abdomen about 3 mm.; head round, width about 2 mm.; middle joints of flagellum about 180 μ long and 225 broad; middle tibia apparently short, broad (breadth about 300 μ), abruptly truncate; middle tarsi slender, first joint about 900 μ long, its outer edge straight on first half and convex on second, third and fourth joints each about 225 μ long, and quite slender; claw joint (excluding claws) about 300 μ long; claws bifid, the two teeth about equally long; hind femora stout but not at all subglobose, about 1500 μ long; hind tibia about as long, about 600 μ broad; basal joint of hind tarsus about 250 μ broad. Outer apical edge of hind tibiae with very broad teeth, with points directed apicad, and long straight or nearly straight upper edges. Wings with a large stigma (solid, filling stigmal cell), its breadth about 300 (this and all following measurements in μ); costal cell very distinct, the costal and subcostal nervures very heavy, and quite wide apart; marginal cell complete, broadly rounded at end, the actual apex not on costa, length of the cell 1500 μ, its tip surpassing apical point of third s. m. by about 100, although the distance from insertion of third t. c. to apex of marginal is about 450; three submarginal cells, the first 1200 long; second very broad, 450 long on marginal, and 900 on cubital nervure, receiving the first r. n. exactly at the middle; third s. m. 600 long on marginal, its outer side strongly bulging; first (upper) section of b. n. less than 300 long, bulging at its lower end, just before the origin of cubital nervure; second (lower) section slightly over 300 long, meeting t. m., which is a little oblique; first discoidal 1500 long; second r. n. joining third s. m. not far from the middle.

Type. — No. 2021, Mus. Comp. Zool. Florissant, Col. (No. 14,292. S. H. Scudder Coll.). Named after Mr. W. J. Fox, in recognition of his work on Engycystis.

Lithotiphia, gen. nov. scudderi, sp. nov.

Length about 12½ mm., anterior wing about 8½; black, the abdomen without light spots; head round, its width 2½ mm.; width of thorax (doubtless increased by crushing) about 4 mm.; abdomen about 6⅔ mm. long and 3 broad; hind femora cylindrical, rather stout, with a little concavity followed by a prominence at apex beneath, as in other Tiphiids; hind tibiae greatly swollen, apparently not dentate; hind tarsi very slender. Wings with apparently a very large stigma, but the microscope shows that this is the stigmal cell, not nearly filled by the long and slender true stigma, which is brown, as long as stigmal cell, but only about 105 (this and all following measurements in μ) broad; the stigmal cell is about 675 long, and 255 broad, broadly truncate posteriorly, and with a rudimentary cross-nervure before the middle, almost meeting the radial nervure (in a modern Scolia I can detect such a cross-nervure, but still more rudimentary); marginal cell entire, exceedingly broadly rounded apically, the actual tip not on costa, length of the cell 1650; three submarginals, the second very broad, 750 long on marginal, receiving the first r. n. nearly 600 from its beginning, and 450 from its end; third s. m. broadly bulging apically, not surpassed by the marginal; length of third s. m. on marginal 750 (same as second s. m.); second r. n. joining third s. m. 375 from its base, and 450 from its lower apical corner; the second r. n. joins the cubital nervure in such a way that the outer angle formed is less than a right angle. B. n. going very slightly basad of t. m., which is strongly oblique.

Type. — No. 2022, Mus. Comp. Zoöl. Florissant, Col. (No. 2440, S. H. Scudder Coll.).

POMPILIDAE.

Hemipogonius florissantensis, sp. nov.

Length nearly 15 mm., anterior wing about 10 mm.; anterior wings with a transverse dark cloud or suffused band at about the end of the basal third, a very large dark roundish patch in and below the marginal cell, and the tip dusky, a round area between the dusky tip and the large dark region appearing white. General structure of body normal, the abdomen sessile, with the first segment, seen in lateral profile, ascending and convex; spurs large; antennae about 7 mm. long, one curled under body reaching middle coxae, apparently not curled, or little curled, at tip; hind coxae long, hind femora about 3½ mm.

Length of stigma 900 (this and the following measurements in μ), its breadth about 285; costal cell distinct; length of marginal cell about 2400, long and narrow, its breadth about 525, its apex pointed and on costa; distance from insertion of third t. c. to tip of marginal, 765; length of first s. m. nearly 2250; first t. c. bowed inwards (basad), its length about 525; stigma to insertion of first t. c., 270; second s. m. on marginal, 750; third s. m. on marginal, 795; outer angle formed by insertion of third t. c. on marginal less than a right angle; distance from insertion of second r. n. to lower apical corner of third s. m., 825 (the second r. n. enters third s. m. toward the base); b. n. *very* far basad of stigma, and its origin 450 basad of t. m., its lower section about 600 long, the upper one (bounding first s. m.) considerably less; lower edge of second discoidal 1275 long, its breadth at apex

800, at base 300. Hind wings with cubital nervure inserted a short distance beyond (apicad of) t. m.

Type. — No. 2023, Mus. Comp. Zoöl. Florissant, Col. (No. 8647, S. H. Scudder Coll.). Easily known from *H. scudderi* by its larger size. The specimen shows several venational characters which were not preserved in *H. scudderi*, and they confirm the generic reference.

Hemipogonius scudderi, sp. nov.

Slender, length about 10½ mm.; antennae 5⅞ mm., the scape thickened; width of head 2 mm.; length of anterior wing about 6½; length of thorax almost 3½; of hind tibia and tarsus about 7; hind spurs large. Wings hairy; stigma distinct; marginal cell sharply pointed on costa, its length and that of first s. m. the same, 1575 μ; greatest width of marginal cell only 405 μ; second s. m. pentagonal, broad, receiving first r. n. a little beyond its middle; length of second s. m. on marginal 450 μ; third s. m. larger than second, shaped as usual; b. n. about 120 μ basad of t. m.; t. m. 255 μ long, not at all oblique. Stigma dark, and a dark cloud in the region of b. n. and below; also a diffused brown cloud occupying marginal cell, the second and third submarginals, and the third discoidal; this region still shows bright iridescent colors. Somewhat allied to the living *H. alienatus* (Smith), but larger. The wings are shorter, and much more strongly clouded, than in *H. fortis* (Cresson) The sutures of the antennal joints are black.

Type. — No. 2024, Mus. Comp. Zoöl. Florissant, Col. (No. 8640, S. H. Scudder Coll.). A beautifully preserved specimen. No. 10,813, S. H. Scudder Coll., is the reverse of the same example.

Ceropalites, gen. nov.

Abdomen very convex, the first point narrowed to a distinct petiole; stigma very well-developed, elongate, lanceolate; subcostal nervure quite widely separated from costa; first discoidal cell very narrow, the part of the basal nervure bounding it being less than half as long as the part bounding first submarginal; b. n. passing only just basad of t. m.; marginal cell large and elongate, probably pointed; antennae long.

Ceropalites infelix, sp. nov.

Length 13 mm.; as preserved, entirely light reddish-brown, probably red in life; wings hyaline, with the apical margin broadly dusky; stigma dark, with a brownish spot immediately below it; length of anterior wing 10 mm.; of abdomen 7; height of abdomen (dorso-ventral) 3; length of thorax anterior to wings 1½ mm.; length of marginal cell over 4 mm. (the apex gone); of wing anterior to stigma about 5⅛ mm.; length of stigma about 1500 μ; its breadth about 375; first section of radial nervure, passing almost straight down from stigma to junction of first t. c., about 450 μ long; width of marginal cell 1095 μ; from first to second t. c. on radial nervure about 1650 μ; beginning of b. n. from stigma, 600 μ; distance of subcostal nervure from costa at this point, 300; first (upper) part of b. n. about 1110 μ, second (lower) part 390; hind part of metathorax with some transverse keels.

Type. — No. 2025, Mus. Comp. Zoöl. Florissant, Col. (No. 6013, S. H. Scudder Coll.). The first abdominal segment having a distinct though short (less than 1 mm. long) petiole is suggestive of Sphecidae, but the insect does not otherwise agree with that group. The first abdominal segment really recalls the winged Mutillidae allied to Photopsis, as much as anything; but the ventral surface of the abdomen is perfectly straight (or rather, gently convex), without the least sign of a depression between the first and second segments. The well-developed stigma is suggestive of Ceropales, but the venation differs from that of any modern genus known to me. I cannot see the third submarginal cell distinctly, but it appears to have been present. The dark spot below the stigma is still slightly iridescent.

VESPIDAE.

Palaeovespa, gen. nov.

With the general form of Vespa, the thorax broadly rounded, and the abdomen sessile and broad at base; the first segment of transverse form, yet by no means so broad as in true Vespa. Venation more like Polistes, the marginal cell being pointed, the apex of first discoidal oblique, and the recurrent nervures joining the second s. m. far apart, not both entering the basal half of the cell, as in Vespa. The b. n. joins the subcostal nervure nearer to the stigma than is usual in Vespa, but not at its base, as in Polistes. It is impossible to see whether the hind wings have an anal lobe or not. This is a very interesting genus, having the appearance rather of Vespa (it would never occur to any one to refer the specimens to Polistes), but retaining the apparently more primitive venation of Polistes, or a close approximation to it. *P. florissantia*, the largest species, is taken as the type, but the characters of the genus are not all ascertainable from the single specimen of that insect.

Palaeovespa florissantia, sp. nov.

Very large and robust; length to beyond middle of fifth abdominal segment, 25 mm.; length from base of abdomen to apex of fourth segment, 14 mm.; thorax narrow for the size of the insect, its width between wings about 7 mm.; breadth of abdominal segments in mm. (1) $6\frac{1}{2}$, (2) $8\frac{1}{2}$, (3) $8\frac{3}{4}$; color dark, evidently black in life, with the hind margins of the abdominal segments broadly but suffusedly pallid; no distinct abdominal markings; wings apparently reddish. The venation is obscure, but the wings appear to be folded, and the very long first discoidal cell of the Vespidae is plainly visible, its length about 10 mm., while its breadth is only about $1\frac{1}{2}$; the lower part of the basal nervure is about 6 mm. long, and the first s. m. on cubital nervure is about $3\frac{3}{8}$; the second s. m., very faintly indicated, appears triangular, the first t. c. oblique, its upper end most distad, the acute angles formed being of about 45°; the apex of the first discoidal, between the first t. c. and the insertion of the first r. n., is obliquely truncate, — considerably more obliquely than in a modern Vespa examined.

Type. — No. 2026, Mus. Comp. Zoöl. Florissant, Col. (No. 11,741, S. H. Scudder Coll.). This is the largest by far of the Florissant Hymenoptera seen

by me. It gives one the impression, at first, of a large Scoliid, but it is unquestionably a member of the Vespidae.

Palaeovespa scudderi, sp. nov.

Length of anterior wing about 13 mm.; of head, including mandibles, 6; of thorax, 8; of middle femur and trochanter 4½; of middle tibia and tarsus, 7; of first discoidal cell, 7; of marginal cell, which ends in a sharp point on costa, 3⅜; eyes deeply emarginate, as usual in Vespa, but contrary to what obtains in the modern species, the part of the eye above the emargination is almost if not quite as large as that below it; mandibles shaped as usual in the genus; the large lateral lobes of prothorax are strongly vertically striate, the striation resembling that found in the same region in species of Myzine and Ammophila; pleura without such striation; head and thorax, dark, doubtless black in life; the middle leg seems to have been black as far as the beginning of the apical third of the femur, or thereabouts, and beyond that yellow or red; apex of first discoidal cell about as in modern Vespa, but narrow; marginal cell much more pointed than in the modern forms, but venation otherwise normal; abdomen missing. Lateral ocellus about 270 μ broad, and 300 from eye; width of marginal cell about 900 μ; of oblique nervure terminating first discoidal, 225 μ.

Type. — No. 2027, Mus. Comp. Zoöl. Florissant, Col. (No. 9065, S. H. Scudder Coll.).

No. 7738, S. H. Scudder Coll., badly preserved, appears to be a second example of *P. scudderi*, as it shows well the striation of the prothoracic lobes; a feature which is not to be seen in any of the specimens of *P. gillettei*, though it may not really be absent. This specimen has the abdomen, and indicates that *P. scudderi* was about 18 mm. long. The hind margins of the last two abdominal segments were broadly light (probably also the two before these), and the light color (no doubt yellow in life) sent a rounded lobe upwards on each side of the last segment, these markings being of the same type as in modern Vespa. The antennae are normal.

Palaeovespa gillettei, sp. nov.

Length about 14½ mm.; of anterior wing about 10 mm., with the nervures more delicate than those of *P. scudderi;* breadth between wings slightly over 4 mm., of abdomen 5; black, with indications on the mesothorax of what appear to have been two longitudinal yellow stripes; venation as in *P. scudderi*, with the same sharply pointed marginal cell; length of first discoidal a little over 5 mm.; width of marginal cell 600 μ. The abdomen is not so broad basally as in modern Vespa; it is nearly parallel-sided, with the broadest part beyond the middle. The species is allied to *P. scudderi*, but smaller in every way, with more delicate venation.

Type. — No. 2028, Mus. Comp. Zoöl. Florissant, Col. (No. 16,325, S. H. Scudder Coll.). No. 2029, M. C. Z. (No. 11,920, S. H. Scudder Coll.), No. 5986, S. H. Scudder Coll., and No. 2030, M. C. Z. (No. 14,305, S. H. Scudder Coll.,) are also Palaeovespa, and presumably the present species, but they do not show the venation so well. The first two show very distinctly

two light lines or narrow bars on mesothorax, not reaching the anterior or posterior margins, and 5986 also shows a narrow light anterolateral margin, probably really on the prothorax, as is common in living forms. The antennae appear to be as in Vespa. Nos. 2031, 2032, M. C. Z. (Nos. 18,382 and 7868, S. H. Scudder Coll.), are two isolated anterior wings of Palaeovespa. They exhibit a good deal of difference in small details, but are, I think, certainly referable to *P. gillettei*. From them it is possible to ascertain several characters not clearly discernible in the type. Both show a dark cloud in the apical part of the costal cell, such as occurs in modern Vespa. The junction of b. n. to subcostal, which in the type is some 450 μ from base of stigma, is only about 300 from it in No. 18,362, and 345 in No. 8981, but it is difficult to say exactly where the basal n. leaves off, and where the stigma begins, the fusion being gradual. The size is throughout too small for *P. scudderi*. The following measurements are in μ:

	Length of second s. m. on marginal.	Length of third s. m. on marginal.
P. scudderi, Type No. 2027, M. C. Z.	450	825
No. 2032, M. C. Z.	345	675
No. 2031, M. C. Z.	225	675

	First r. n. from beginning of second s. m.	First r. n. (on cubital n.) from second r. n.	Second r. n. from end of second s. m.
P. scudderi, Type No. 2027, M. C. Z.	225	665 ?	375 ?
P. gillettei, Type No. 2028, M. C. Z.	?	?	225 ?
No. 2032, M. C. Z.	150	535	375
No. 2031, M. C. Z.	150	375	300
Vespa (modern)	195	240	750

P. gillettei is named after Professor C. P. Gillette, in recognition of his work on the entomology of Colorado.

EUMENIDAE.

Odynerus palaeophilus, sp. nov.

♀ Rather slender, length 9 mm., anterior wing 8 mm.; black, the wings dusky; first abdominal segment in lateral profile (*i. e.* seen from the side) presenting a curve which is uniform, not abruptly bent at any point, and is equal to about a quarter of a circle; abdomen broad and convex, with the apical part separated, doubtless originally marked off by a suture, as in some living forms; marginal cell very broad, in the form of an elongated triangle, the apex downwards; apex of first discoidal only moderately oblique (much less so than in a modern species compared); second submarginal cell narrowed almost to a point above, its length on marginal being only 60 μ, while its length on cubital nervure is 555 μ; width of marginal cell, 600 μ; width of third s. m. on marginal, 525 μ. It would be easy to misinterpret the venation of this insect (as also of the species of *Palaeovespa*), owing to the folding; but it is easily understood when compared with modern

examples similarly folded. This insect has the closest possible resemblance to a species still living in Colorado, but it differs in the venation in two respects: (1) the second submarginal cell is more contracted above, (2) the cubital nervure is abruptly bent at the end of the first discoidal cell, as in Vespa, whereas in the modern species it is straight.

Type. — No. 2033, Mus. Comp. Zoöl. Florissant, Col. (No. 10,657, S. H. Scudder Coll.)

Odynerus praesepultus, sp. nov.

♀ Black, apparently with two light longitudinal bars on mesothorax; length nearly 11 mm., head and thorax about 4 mm., anterior wing 7 mm.; wings folded, somewhat reddish; flagellum thick, (the end tapering, not clavate,) dark above, light below; abdomen sessile, second segment not swollen, dorsally or ventrally; in lateral profile, the dorsum of abdomen is gently curved, the venter nearly straight, no segment markedly different from the one before it. Stigma large, its width (short diameter) about 200 (this and other measurements in μ); marginal cell subtriangular, 1350 long, about 450 broad, narrowly obliquely truncate, the truncation about 150 broad; tip of marginal cell about level with apex of third s. m.; b. n. inserted at base of stigma, its upper section about 450 long; first s. m. 1425 long; stigma to insertion of first t. c., 450; second s. m. much narrowed above (150 long on marginal), and receiving both recurrent nervures; first r. n. from origin of first t. c., 250 (lower basal corner of second s. m. very acute); distance between insertion of first and second r. n., 300; cubital nervure not at all bent at end of first discoidal; insertion of second r. n. to origin of second t. c., 105; lower margin of third s. m., 600; third s. m. on marginal, 450; insertion of third t. c. to apex of marginal cell, 450.

Type. — No. 2034, Mus., Comp. Zoöl. Florissant, Col. (No. 11,944, S. H. Scudder Coll.). This is readily known from Palaeovespa by (1) marginal cell obliquely truncate at end, the tip not on costa; (2) cubital nervure not at all bent at end of first discoidal, (3) b. n. originating at base of the very large stigma. It appears to be one of the Eumenidae, the venation agreeing with that group better than with the Vespidae. Among the Eumenidae, from the venation and structure of the abdomen, it can go only in Odynerini, and it is referred to Odynerus in the old, broad sense. The modern genera of Odynerini are separated mainly on characters which are not discernible in the fossil.

ICHNEUMONOIDEA.

STEPHANIDAE.

Protostephanus, gen. nov.

Head rounded or subquadrate, rugose or tuberculate; prothorax broad but produced, with a median longitudinal groove, and fine lateral oblique striae; abdomen sessile; hind coxae elongated, about $\frac{2}{3}$ the length of their femora; hind femora moderately stout, not toothed; stigma rather large; costal cell very distinct; terminal part of subcostal nervure, for a distance nearly equal to the length

of the stigma, much thickened and appearing black; marginal cell long and quite narrow; b. n. strongly bent at beginning of cubital nervure; t. m. opposite b. n., the latter very slightly more basad; only one s. m., which is considerably broader than the first discoidal; first r. n. meeting first t. c., which is continued in a straight line with it, making, with the cubital nervure, a large ×. This interesting genus differs from those hitherto known by the combination of an elongated prothorax, unarmed hind femora, and sessile abdomen.

Protostephanus ashmeadi, sp. nov.

Length about 9⅓ mm.; anterior wings clear, with brassy iridescence still showing, their length about 6 mm.; hind coxae transversely striate; hind tibiae claviform, swollen apically, the hind tibiae and tarsi about as long as hind coxae and femora, but the tibiae somewhat longer than the femora; pleura finely striate; measurements in μ: — width of head about 1500; length of thorax anterior to wings about 1200; length of hind coxae about 1200; width of hind tibiae at apex about 450; breadth of hind femora about the same; extension of abdomen beyond apex of hind femora perhaps 1500; breadth of stigma about 180; breadth of marginal cell about 300; length of first (and only) s. m. 975; length of first discoidal, 900; length of the quadrate second discoidal about 795; length of t. m. not quite 300; length of second section of b. n. (bounding first discoidal) about 450.

Type. — No. 2035, Mus. Comp. Zoöl. Florissant, Col. (No. 13913, S. H. Scudder Coll.). Named after Mr. W. H. Ashmead, whose writings were most useful in determining the affinities of the insect.

Bulletin of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. L. NO. 3.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, TO MARCH, 1905, LIEUT. COMMANDER L. M. GARRETT, U. S. N., COMMANDING.

VI.

MADREPORARIA.

BY T. WAYLAND VAUGHAN.

WITH TEN PLATES.

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AUGUST, 1906.

No. 3. — *Reports on the Scientific Results of the Expedition to the Eastern Tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross" from October*, 1904, *to March*, 1905, Lieut. Commander, L. M. Garrett, U. S. N., Commanding.

VI.

Madreporaria. By T. Wayland Vaughan.[1]

Mr. Alexander Agassiz has submitted to me for determination and report the Madreporaria collected during the "Albatross" Expedition of 1904–1905. The collections are small, and represent only seven localities.

Two species, *Pocillopora lacera* Verrill and *Astrangia haimei* Verrill, were obtained from Taboguilla Island, Bay of Panama, the former at a depth from low tide to 1 fm., the latter between tides.

Three species were obtained in the vicinity of the Galapagos Islands, viz. : —

Madrepora galapagensis, sp. nov., depth 300 fms.
Desmophyllum galapagense[2], sp. nov., depth 300 fms.
Balanophyllia galapagensis, sp. nov., depth 100 fms.

One species, *Bathyactis marenzelleri*, sp. nov., was collected off Callao, Peru, at a depth of 3,209 fms. The same species was obtained at Station 4721, about half way between the Galapagos and Garrett Ridge, at a depth of 2,084 fms., and probably at Station 4732, southwest of Garrett Ridge, at a depth of 2,012 fms.

Two species, *Pocillopora diomedeae* and *Porites paschalensis*, both new species, were collected on the shore of Easter Island.

Five species, a variation of *Pocillopora cespitosa* Dana and four species of Acropora, were obtained at Manga Reva.

[1] The Director of the U. S. Geological Survey has allowed me to prepare this Report as part of my official work.

[2] The name *Desmophyllum galapagensis*, on Plate 1 printed as originally proposed, has been changed to the more correct *D. galapagense*.

The two shore species from Taboguilla are well-known Panamic forms. The two from Easter Island group with species known from the South Pacific and Indian Ocean. The species from Manga Reva belong to the fauna of the Southwestern Pacific and Indian Ocean.

The literature on the deep-sea Madreporaria of the Eastern Pacific is almost nil. Moseley, in his "Deep-Sea Corals" obtained by the "Challenger" Expedition, described a few, and Dr. von Marenzeller has published a report on the "Stein- und Hydro-Korallen" collected off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, by the "Albatross" in 1891.[1] He records eight species of Madreporaria, five of which are specifically identified, viz.: —

Desmophyllum cristagalli M. Edw. & H.
Caryophyllia diomedeae von Marenzeller.
Madrepora oculata Linné.
Cladocora arbuscula (Le Sueur).
Bathyactis symmetrica (Pourtalès).

I am able to add four species. There is a considerable quantity of unstudied deep-sea material from the Pacific coast of America in the United States National Museum, but I have not as yet been able to describe it. However, I hope to do so within a short time in connection with monographing the Tertiary coral faunas of the Western United States. The Hawaiian Expedition of the "Albatross," 1902, was fortunate in procuring a considerable collection of deep-sea Madreporaria. I have described that collection for the United States Bureau of Fisheries, and found it very interesting for comparison with the faunas of the Southwestern Pacific and Indian Ocean on one side and that of Western America on the other.

These notes are presented to show the meagerness of our knowledge of the deep-sea Madreporaria of the greater portion of the Pacific Ocean. We do not yet know enough to undertake the discussion of the broader problems of geographic distribution. The collection made by the "Albatross" in 1904–1905, though small, is interesting and important, as it makes a distinct addition to our knowledge of Pacific deep-sea Madreporaria.

The Panamic specimens are omitted from the following discussion of the species.

[1] Bull. Mus. Comp. Zoöl., **43**, p. 75–87, 3 pls., 1904.

Desmophyllum galapagense, sp. nov.

Plate 1, figs. 1-1b.

Corallum curved, attached by an expanded base; transverse outline of calice, elliptical.

Measurements: height, 15 mm.; diameter immediately above basal expansion, 2.5 mm.; greater diameter of calice, 6.75 mm., lesser, 6 mm.

The corallum wall is very thin, its outside is polished and glossy, but shows minute transverse lines of growth that are parallel to dentations on its upper edge which correspond in position with the septa.

Septa thin, in four complete cycles, primaries and secondaries of equal size, with exsert margins, about 1.5 mm., tertiaries shorter, quaternaries still smaller and may be rudimentary. The septal faces granulated, granulations small, showing arrangement parallel to the septal margin and also in linear series.

Calicular fossa very deep and narrow. No columella.

Locality: — Station 4642, southeast face of Galapagos Islands, 5 miles from southeast end of Hood Island; depth, 300 fms.; bottom, broken shells and Globigerina; temperature of the bottom, 48.6° F. The specimen grew attached to *Madrepora galapagensis*, sp. nov.

Remarks: — *Desmophyllum galapagense* is close to *D. alabastrum* Alcock, but the latter species has the third and fourth cycles of septa buried "in the depths of the cup where at first they escape notice." It is very close to *D. eburneum* Moseley, and may ultimately be combined with that species, it differs from the latter, however, by the entire absence of costae, and none of the primary septa bend outward beyond the margin of the calice.

Madrepora galapagensis, sp. nov.

Plate 1, fig. 2; plate 2, figs. 1-1b.

Corallum in its basal portion thick and compact; branches anastomosing. The colonies evidently attain considerable size. The terminal branchlets are stout, rather short, with thick bases. One branchlet measures 20 mm. in length, 7 mm. in diameter at the base, terminal calice 4.5 mm. in diameter. Some branchlets are shorter, others are longer, and the terminal calice may not have so great a diameter, but the branchlets are constantly relatively thick.

The calices on the branches are usually dichotomous in arrangement, occasionally there is opposite gemmation in a plane at right angles to the plane passing through the middle of the dichotomous calices. On the older portions of the corallum the coenenchyma is very highly developed and there is no definite calicular arrangement.

The fully developed terminal calices are about 4.5 mm. tall, and about 4 mm. in diameter measured between the thecal summits; 4.5 mm. is probably the maximum calicular diameter on a branchlet. On the basal portion of the corallum the calices are as much as 10 mm. apart, and range in diameter from 2.5 to 3.5 mm. in diameter. They are deep, even exceeding 3 mm. The elevation of the calicular

margins is variable, ranging from 1 mm., or even less, to 5 mm. At and just below the calicular margins are costae corresponding to the primary and secondary septa, they usually are not continued far down the outside of the corallite wall.

The coenenchyma is highly developed, absolutely solid, its surface striate, or checkered by superficial canals.

Septa in three complete cycles, the primaries are exsert between .5 and 1 mm., the secondaries less prominent, the tertiaries with scarcely elevated margins. The inner margins descend abruptly, those of the first two cycles extend to the axis, and may or may not form a weak, false columella. The septal faces are striate and granulate, septal edges entire.

The corallite cavities are solidly filled below by stereoplasm.

Locality: — Station 4642, southeast face of the Galapagos Islands, 5 miles from southeast end of Hood Island; depth, 300 fms; bottom, broken shells and Globigerina; temperature of the bottom, 48.6° F.

Remarks: — This species belongs near *Madrepora oculata* (Linné) but differs in its shorter, relatively thicker branches, and its more prominent and deeper calices.

Pocillopora cespitosa Dana var.

Plate 3, figs. 1-1b.

1846. *Pocillopora cespitosa* Dana, Zooph. Wilkes Expl. Exped., p. 525, plate 49, figs. 5, 5*a*.
1846. *Pocillopora brevicornis* (pars) Dana, Zooph. Wilkes Expl. Exped., p. 526.
1860. *Pocillopora cespitosa* Milne Edwards, Hist. nat. Corall., **3**, p. 303.
1869. *Pocillopora caespitosa* Verrill, Proc. Essex Inst., **6**, p. 91.
1886. *Pocillopora cespitosa* Quelch, Reef Corals, "Challenger" Rept., p. 66.
1901. *Pocillopora caespitosa* Studer, Zool. Jahrb. Syst., **40**, p. 399.

One specimen was obtained. It is a clump 8 cm. tall, 10.5 cm. long, and about 8.8 cm. wide. It is composed of rather crowded, compressed branches, that bear verruciform branchlets. In form it resembles the stylophoroid variety of the species found in the Hawaiian Islands. The septa and columella are distinct, especially on the basal portion of the corallum, where the latter is often styliform.

For a description of the variations of this species, my report on the Hawaiian Madreporaria, U. S. Bureau of Fisheries Bulletin, should be consulted.

Locality: — Motus reef flats, Manga Reva, Paumotus.

Pocillopora diomedeae, sp. nov.

Plate 2, figs. 2, 2a; plate 6, fig. 1.

Corallum composed of short, subterete or compressed elliptical, or wide, flattened blunt branches, the ends sometimes incrassate or subclavate. Seven broken branches were obtained, probably all belonging to the same colony, and because of the darker, reddish color of the lower ends the total length is probably represented.

Specimen.	Length.	Diameter of Lower End.		Diameter of Upper End.		Shape of Upper End.
		Greater.	Lesser.	Greater.	Lesser.	
1	46 mm.	17 mm.	11 mm.	7 mm.	5 mm.	Obtuse.
2	45	14	12.5	13	9	Obtuse, subclavate.
3	55	11	10	21	10	Obtuse, incrassate.
4[1]	67	15	12	14	10	Obtuse.
5	59	15	13.5	22	14	Obtuse.
6	69	22	17.5	32.5	16.5	Obtuse, bifurcation 22 mm. below upper end.
7	66	30	12	42.5 38.5	12 16	Obtuse, bifurcation 36.5 mm. below upper end, measurements given for each branch.

[1] The specimen figured.

Verrucae obsolete or irregular in development. They may bear from three to five calices, scarcely elevated above the usual level of the surface of the branch, or may be as much as 3.5 mm. tall and covered by as many as 20 calices. The larger verrucae are appressed, greater diameter 6 mm., lesser, 3.5, with the apices distally directed. They are better developed along the more compressed edges than on the flatter sides. Their distance apart is too variable to possess any systematic value.

Calices with slightly elevated margins; deep over the whole surface, about 1 mm. near the lower end. The apical ones are separated by narrow, acute walls and have a maximum diameter of 1.5 mm.; those on the sides, about 30 mm. below the apex, are 1 mm. in diameter and are separated by walls from .5 to .75 mm. thick; those near the base (65 mm. from the apex), are about .75 mm. in diameter and are separated by an equivalent thickness of coenenchyma. The calices on the verrucae are about 1 mm. in diameter and are closer together than on the adjacent portions of the side of the corallum.

Septa are indistinct in the apical calices, distinct in practically all others, but somewhat irregular in development, usually best developed near the lower end of the branch. The number is twelve, two complete cycles, with occasional members of the third. A varying number, from one to six, are much thickened and have very exsert edges; but all, excepting one or both of the directives, are narrow, rendering the fusion to the columella invisible from above. The inner margins are spinulose. The columella is usually well developed, arises deep down in the

calice; it is rather thick and terminates in one or several prominent ascending spines.

The coenenchyma is usually very dense, its surface beset with isolated, erect, compressed, truncated spinules. A circle of more prominent spinules surrounds each calicular cavity, those intervening usually less prominent.

The corallites cavities often solidly filled with internal deposit, rendering the corallum very dense; tabulae, when present, from .5 to 1 mm. apart.

Locality: — Shore, Easter Island.

Remarks: — This is the most distinctly characterized species of Pocillopora that has come under my observation, as I know no other that is really very similar. The thick branched or frondose species in which the septa are well developed and the columella prominent are *P. modumanensis* Vaughan (Hawaiian Islands), *P. ligulata* Dana, *P. plicata* Dana, *P. coronata* Gardiner, *P. eydouxi* M. Edw. and H. and *P. elongata* Dana. *P. rugosa* Gardiner has in the lower calices a slender very prominent columella, but the septa are very indistinct; *P. capitata* Verrill, from Panama, in some of its variations appears to have distinct septa and a styloid columella. The only species whose name is listed above with which *P. diomedeae* need be compared is *P. elongata* Dana. *P. elongata* has longer, thicker branches, more uniformly developed and uniformly distributed verrucae, the columella (judging from Verrill's redescription of the type)[1] is not so thick, and the texture much more porous. It is very probable that the exsert margins of a portion of the septa in *P. diomedeae* and the compressed, truncated granulations of its coenenchyma constitute additional differences.

Bathyactis marenzelleri, sp. nov.

Plate 4, Figs. 1-1 b.

Base of the corallum circular, 22.5 mm. in diameter, almost flat, slightly concave in the middle. The wall is extremely thin and translucent. Thin, slightly wavy costae correspond to all septa, but become obsolete on the central portion of the base; those corresponding to the last cycle smaller and more irregular in development. The costal edges are irregularly, sometimes coarsely, dentate.

The calice is superficial, almost everted. Septa extremely thin, in four complete cycles, forming six septal groups, one group between each pair of primaries. The tertiaries fuse by a kind of calcareous membrane to the included secondary, and the quaternaries fuse nearer the wall by their inner margins to the included tertiary. There is an occasional rudiment of a fifth cycle. The margins of the primaries are very tall, projecting 9 mm. above the base, the secondaries are almost as prominent as the primaries, the tertiaries are slightly less prominent than the secondaries, the quaternaries are decidedly less prominent than the other septa. The outer portion of the septal margins is irregularly lacerate, the inner half between the columella and the periphery possesses from three to four distant, tall, erect, thin, spines. Septal faces without granulations, fluted, with distant carinae, some of which connect below with synapticula. These carinae vary from

[1] Proc. Essex Inst., 6, p 99, 1869.

somewhat less than 1 mm. to almost 2 mm. apart. From three to five thin, membraniform synapticula, formed by the basal fusion of opposed carinae, occur in each interseptal loculus.

The inner ends of the septa are united by a calcareous membrane, through which small, thin, spinose, septal processes project. The diameter of the columella platform is 5 mm.

Localities: — (*Type*) — Station 4721 between Galapagos and Barrett Ridge ; depth 2,084 fms. ; bottom, light brown Globigerina ooze, sponge, spicules, diatoms, a few Radiolaria; thermometer failed to register on the bottom; 1 specimen.

Station 4670 western edge of Milne Edwards Deep off Callao ; depth 3,209 fms. ; bottom, soft, light brown mud ; temperature of the bottom, 35.4° F.; 3 specimens, partially decalcified, two were cleaned by boiling in a solution of caustic potash, and were easily identifiable.

A specimen of Bathyactis, which had been decalcified, was dredged at station 4732, between Barrett Ridge and Manga Reva, at a depth of 2,012 fms. This specimen is not specifically identifiable, but probably belongs to *B. marenzelleri*. Bottom, light gray, Globigerina ooze, sharks' teeth, and ear bones, manganese nodules, very few diatoms and radiolaria, sponge spicules ; temperature of the bottom, 34.8° F.

Remarks: — This species according to Alcock's synopsis of the species of Bathyactis [1] obtained by the " Siboga " is nearest to *B. symmetrica* (Pourtalès), as it possesses no pali and only four cycles of septa. But it differs markedly from that species. The shape of the septa and the character of their margins are entirely different — the great elevation of the septal margins and their peculiar laceration are very striking. *B. sibogae* Alcock is similar to *B. symmetrica*, differing by possessing five, instead of four, cycles of septa. *B. stephana* Alcock possesses elevated septal margins, but the base of the corallum is concave and there are five cycles of septa. Alcock's figure [2] of the last named species indicates that its septal margins are peripherally narrow or excavated, and that they are elevated near the calicular fossa, the reverse of the condition in *B. marenzelleri*. *B. hawaiiensis* Vaughan has a general similarity in form, but it possesses five cycles of septa, its septal margins are not so lacerate and the carinae on the septal faces are much more crowded, and bear spinose granulations. It therefore seems that *B. marenzelleri* is decidedly different from any other hitherto discovered species of the genus.

Balanophyllia galapagensis, sp. nov.

Plate 4, Figs. 2-2 b.

Corallum elongate, slightly curved, with broadly elliptical transverse outline. The lower end is broken and the calicular margin is somewhat, but not greatly, damaged. The following are the measurements: length, 20.5 mm.; lower end,

[1] Deep-Sea Madreporaria of the Siboga Exped., p. 37.

[2] Investigator Deep-Sea Madreporaria, plate 3, fig. 5*a*.

greater diameter, 6.5 mm., lesser, 5.5 mm.; upper end, greater diameter, 7 mm., lesser, 5.5 mm.

The upper edge of the wall is rather thin, but below it is very much thickened — there is so much internal deposit that practically the whole of the internal structures are obliterated. An incomplete, pellicular epitheca extends to within 5 mm. of the calicular edge. The wall is costate, the costae are perforated, low, subacute, and granulated on the edge, with narrow, perforated intercostal furrows. Every fourth costa is slightly larger than those intervening.

The septa are in four complete cycles, the primaries and secondaries are equal and extend directly to the columella, the tertiaries are included between the distally diverging quaternaries, which fuse before the tertiaries and are connected by a plate with the columella. The primaries, secondaries, and quaternaries are thick, the tertiaries are decidedly thinner. The septal margins are only slightly exsert, arched above, the inner margin falling perpendicularly to the periphery of the columella. The septal faces are densely beset with obtuse or truncated granulations, which, especially near the septal margins, show serial arrangement.

The columella is large and prominent, greater diameter, 3.5 mm., half the greater diameter of the calice; lesser diameter, about 2 mm., one-third the lesser diameter of the calice. Its upper surface is slightly domed, rising above the level of the septal fusion to its sides. It is composed of thin curled flakes that are united one to another by synapticula.

The calicular fossa is shallow, about 1.5 mm. its maximum depth.

Locality: — Station 4643, southeast of the Galapagos Islands, about 4½ miles west by south from the west end of Hood Island; depth, 100 fms.; bottom, broken shells and Globigerina; temperature of the bottom, 67.2°.

Remarks: — This species is so peculiar that I do not know of any other one with which to compare it. It presents only generic similarity to *B. elegans* Verrill, from the Pacific coast of the United States, and it is not closely related to any of the Hawaiian species of Balanophyllia known to me. Probably *B.* (*Thecopsammia*) *gemma* Moseley is the most similar, but *B. galapagensis* is much more elongate, and differs in the details of the septal arrangement.

ACROPORA Oken.

Four specimens belonging to this genus were obtained from Manga Reva. One specimen is incrusted with nullipores and is not in condition for positive specific determination, it, however, is closely related to *Acropora* (*Tylostoma*) *humilis* (Dana) and may belong to that species.

It is with a feeling of positive regret that I describe two supposedly new species of this genus, but I have been utterly unable to refer them to any described species.

Acropora mangarevensis, sp. nov.

Plate 6, Fig. 2; Plate 8, Fig. 1.

Corallum rising from a stout pedicel, 61 by 35 mm. in diameter, irregularly vasiform, fusion of the branches imperfect near the periphery. Height of specimen, 20 cm.; diameter of vase, 24.5 cm.; depth of vase, 7.7 cm.

The upper surface is occupied by short erect branches, which are conical in shape in the central portion. One of the central branches is 14 mm. in diameter at the base, and 14 mm. in height. Outside the central area, as the wall of the vase slopes rather steeply, the outer angle between a branch and the branch from which it rises or the common wall, is acute. The maximum length of the free portion of a branch is 27 mm.; the branches are radially compressed, diameter along a radius 12 mm. (a little more than 1 cm.), perpendicular to a radius 1 cm. or slightly less. Apices from 1 to 2 cm. apart. Nearly all the branches bear branchlets or proliferous calices.

Calices on the expansion below the pedicel immersed, from the base of the pedicel to the upper edge the immersed calices become progressively fewer, while slightly protuberant ones become more numerous. Apertures labellate or circular; the inner wall may or may not be elevated. The maximum height of these external corallites is about 2 mm.; diameter of base about 2 mm.; calicular diameter about 2 mm.; diameter of aperture about .75 mm. The corallites decrease in diameter toward the calices very slightly. Corallite wall costate, perforate. The corallites of the upper surface are immersed between the bases of the branches, about 1 mm. in diameter; on the branches there are immersed corallites, the other corallites may be labellate with only the outer wall developed, nariform or tall and proliferous. The diameter of the calicular aperture is about .75 mm., one of the long corallites is 3.5 mm. in length. The apical corallites are frequently aborted, when present, 1.75 mm. is probably an average diameter, projecting about 1 mm. The corallite walls are acutely costate, and often imperforate except near the upper edge.

Two cycles of septa are uniformly well developed, the directives more pronounced.

Coenenchyma echinulately striate, perforate, but with a tendency to compactness.

Locality: — Manga Reva.

Remarks: — I do not know of any other species that closely resembles this one; there is a superficial resemblance to all other vasiform, or palmate Acroporae, but there the resemblance, so far as my knowledge goes, stops.

Acropora diomedeae, sp. nov.

Plate 7, Figs. 1, 1 a; Plate 8, Figs. 2, 3.

Corallum vasiform, with a pedicellate base. The branches fusing completely except near the periphery.

Height, 20.7 cm.; diameter of vase, 32 cm.

The upper surface is occupied by short erect, or sub-erect branches that rise from a common plateau. They are irregular in height and diameter, between 3 and 3.5 cm. tall near the periphery, and 8 mm. in diameter at the base; at the center the height is about 2.5 cm., diameter at base may be as little as 7 mm. The distance apart of the bases is usually less than 1 cm., 6 to 8 mm. Very few of the branches are single, finger-like processes, most of them bear less developed lateral branchlets or proliferous calices.

Calices of the lower surface immersed near the lower edge of the pedicel; some, but a very few, are immersed on the bowl portion of the vase. The other calices slightly elevated, appressed, with distally directed, circular apertures. The corallites are

tubular, with complete inner walls. The length varies up to 5 mm., aperture above the surface up to 2.5 mm.; calicular diameter of the corallites about 1 mm., basal 1.5 mm. Walls perforate, sharply costate. The calices of the upper surface represent several types: (a) those between the bases of the branches are immersed; (b) on the branches; apical corallites tubular, 1.5 mm. in diameter, projecting as much; calicular aperture .75 mm., walls sharply costate and perforate; the lateral calices are of at least three kinds, elongated, proliferous calices that may develop branchlets; ascending calices with very oblique apertures, height may be as much as 4 mm., diameter about 1 mm. The inner wall is rarely or never so well developed as the outer, but it is rarely absent; the outer lips of the calices are sometimes curved inward. In addition to the proliferous and simple ascending lateral calices, there are immersed or subimmersed calices, which become more numerous towards the base of the branch.

Septa in the apical corallites, six; in the lateral corallites of the branches the directives are distinct, the others are usually rudimentary. The septa of the under surface are very variable in development. There may be from less than six to two complete cycles.

Coenenchyma porous and echinulate.

Locality: — Manga Reva.

Remark: — This is the only vasiform Acropora whose calices have only six septa known to me.

Acropora aff. canaliculata (Klunzinger).

Plate 5, Figs. 1-1b.

1879. *Madrepora canaliculata* Klunzinger, Korallenth. Roth. Meer. **2**, p. 12, Plate 7, Fig. 3, Plate 4, Fig. 10, Plate 9, Fig. 8.

I have been unable to decide positively to what species a piece of a corallum from Manga Reva should be referred. It belongs to Brook's subgenus Tylopora, to Section C of that subgenus, and to subdivision *b* of Section C. It groups with *A. seriata*, *A. pyramidalis*, and *A. canaliculata*. I have considered it nearer to *A. canaliculata* because of practically complete agreement with Klunzinger's figures of the general habit of the corallum, and the detail of a single branch, Plate 7, Fig. 3, Plate 4, Fig. 10. As three figures are given of the Manga Reva specimen, a detailed description is not necessary. The branchlets are rather thicker than Klunzinger's figures indicate, and the apical corallite is 4 mm. in maximum diameter. The radial calices are of three kinds; some are sunken, others in which the upper wall is wanting, and still others with a developed upper wall, among the last are occasionally some that are subtubular. The tubular calices are slightly dilated at the mouth. No calices with a longitudinal slit in the upper wall, such as is represented in Klunzinger's Plate 9, fig. 8 c–d, were seen;

fig. 8 e–f represent the usual condition very well. I wish to call attention to four possible differences between the Manga Reva specimen and *A. canaliculata* : — 1. the somewhat thicker branches ; 2. its slightly smaller apical corallites ; 3. the absence of radial corallites with slit upper walls ; 4. the occurrence of a few calices that are slightly dilated at the mouth. Of these differences, No. 3 can probably be entirely discarded, as the usual form of the calices corresponds to that for *A. canaliculata.* The other differences are in degree. I therefore think that the Manga Reva is *A. canaliculata,* but with so little material a positive identification is hazardous.

Locality : — Outer edge, Motus reef flats, Manga Reva.

Porites paschalensis, sp. nov.

Plates 9, 10.

Corallum attached by a large base, increasing in diameter as it grows upward, upper surface flat, with rather wide shallow furrows and some circumscribed depressions. Height of largest specimen 15 cm., greatest distance across the top, 22 cm. Plate 9 gives two views, natural size, of a smaller specimen, and shows the mode of growth.

Calices polygonal, varying greatly in size ; on the more elevated portions of the upper surface they may be fully 2 mm. in diameter, while in neighboring depressions the diameter may be scarcely 1 mm. ; on the sides 2 mm. is the maximum diameter. The variation in depth is considerable, on the upper surface relatively deep, between .5 and .75 mm. ; on the sides, shallow.

The walls between neighboring calices are thin, elevated, with numerous perforations between the synapticula joining the component trabeculae ; the upper edge is spinulose, and with spinules more numerous than the septa, the spinules irregularly granulated. On the sides of the corallum, within the wall and at a lower level is a fairly regular ring of thick synapticula, above each of which is a frosted granulation. The trabeculae forming this ring are what Bernard calls the "wall trabeculae."[1] There is intervening between the mural trabeculae and the pali usually a ring of elevated, pointed spines, Bernard's "septal granules," which equal in height the mural granules and exceed that of the pali. The pali are distinct low points. The columella is a compressed tubercle, situated in a depression.

The dorsal, solitary, directive and the lateral pairs bear pali as is usual in the genus. The members of the ventral triplet are not intimately united, although their ends are joined by the palar ring. The middle septum of the triplet may bear a palus, but usually in this group the septal granules simulate pali and seem to form part of the palar ring.

The preceding description of the wall and septa is based upon the calices on the sides of the corallum ; on the top, the wall ridge is decidedly

[1] Cat. Madrep. Corals, Brit. Mus. 5. The Genus Porites, p. 14, 273, 1905.

more elevated, but the septa, although distinct and arranged as on the sides, do not have the various trabecular elements so clearly differentiated, the latter, however, are the same in number and arrangement on both sides and top.

Locality: — Easter Island.

Remarks: — This species belongs in division "B" of Bernard's "Analysis and distribution of types of calicles," "Forms in which one ring of extra, intervening, or costal trabeculae appears typically in the walls."

There are four forms in Bernard's Catalogue of Porites to which the one under consideration is closely related, they are:

1. P. Fiji Islands (24) 4, p. 46.
2. P. Ellice Islands (17) 8, p. 70.
3. P. Ellice Islands (17) 9, p. 72.
4. P. Ellice Islands (17) 10, p. 73.

The calices of the last three are somewhat smaller than in the Easter Island form; the resemblance to the first is extremely close, but its skeleton seems denser. As none of the forms with which comparison is made have been named specifically, the validity of *P. paschalensis* is not affected should it prove identical with one of them.

EXPLANATION OF PLATES.

PLATE 1.

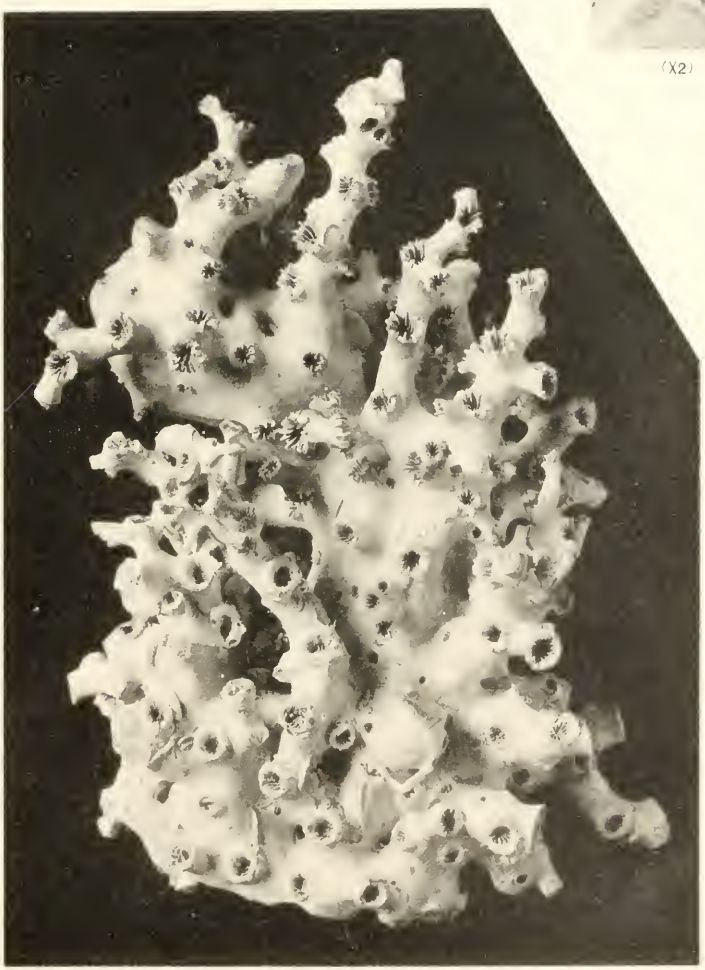
FIGS. 1, 1*a*, 1*b*. Desmophyllum galapagense, sp. nov., p. 63. Fig. 1, upright view of corallum, height, 15 mm.; fig. 1*a*, calicular view, greater diameter, 6.75 mm.; fig. 1, view of the edge of the wall, × 4.

FIG. 2. Madrepora galapagensis, sp. nov., p. 63. General view of a corallum, natural size.

(X4) 1b

(X3) 1a

(X2) 1



2

FIGS. 1-1B. DESMOPHYLLUM GALAPAGENSIS.

FIG. 2. MADREPORA GALAPAGENSIS.

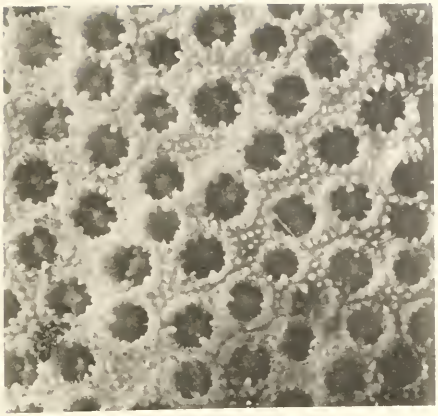
HELIOTYPE CO., BOSTON.

PLATE 2.

Figs. 1, 1*a*, 1*b*. Madrepora galapagensis, sp. nov., p. 63. Fig. 1, view of a single branch, natural size; fig. 1*a*, the same branch, × 2; fig. 1*b*, a calice, × 4.

Figs. 2, 2*a*. Pocillopora diomedeae, sp. nov., p. 65. Fig. 2, general view of a branch, natural size; fig. 2*a*, calices, enlarged about 8 times.

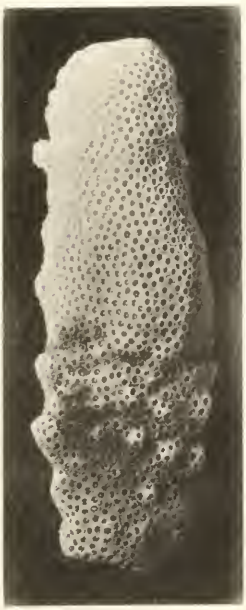
1



2a

(x4) 1b

1a



2

FIGS. 1-1B. MADREPORA GALAPAGENSIS.

FIGS. 2-2A. POCILLOPORA DIOMEDEAE.

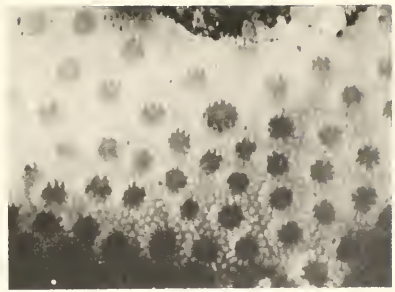
PLATE 3.

Pocillopora cespitosa Dana var., p. 64.

FIG. 1. General view of the corallum, natural size; fig. 1*a*, calices enlarged about 8 times; fig. 1*b*, a single calice more enlarged, rendered somewhat diagrammatically.

1

1b



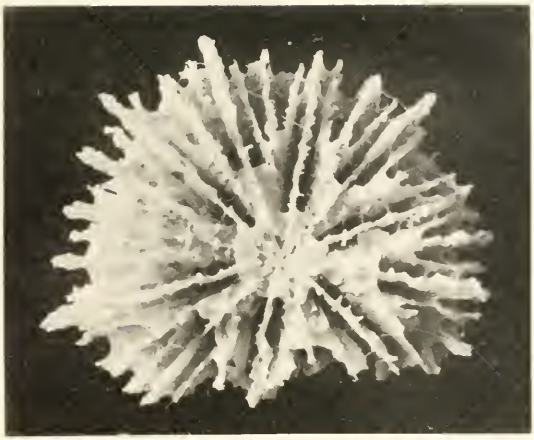
1a

POCILLOPORA CESPITOSA, VAR.

PLATE 4.

Figs. 1, 1*a*, 1*b*. Bathyactis marenzelleri, sp. nov. p. 66. Fig. 1, calicular view, × 2; fig. 1*a*, basal view, × 2; fig. 1*b*, side view of a septum, × 4.

Figs. 2, 2*a*, 2*b*. Balanophyllia galapagensis, sp. nov., p. 67. Fig. 2, upright view of corallum, × 2; fig. 2*a*, calicular view, × 3; fig. 2*b*, costae, × 4.



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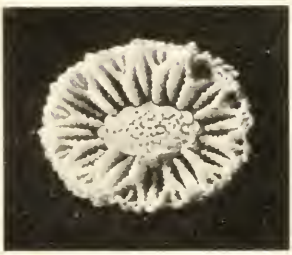
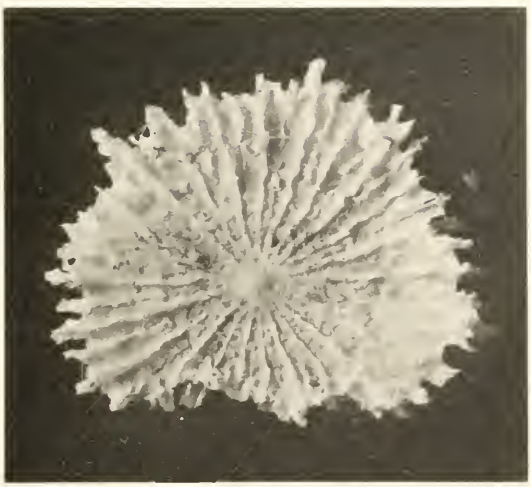
2

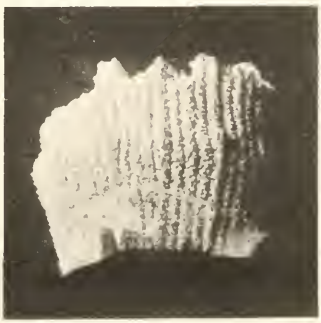


2a



1a

1b



2b

FIGS. 1-1B. BATHYACTIS MARENZELLERI.

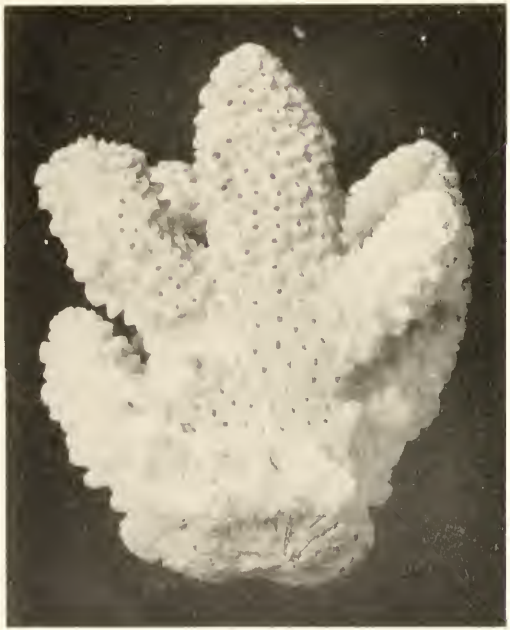
FIGS. 2-2B. BALANOPHYLLIA GALAPAGENSIS.

HELIOTYPE CO., BOSTON.

PLATE 5.

Acropora aff. canaliculata (Klunzinger), p. 70.

FIGS. 1, 1*a*. Two general views of the corallum, natural size; fig. 1, apical corallite, enlarged about 3 times.



1

1b

1a

ACROPORA AFF. A. CANALICULATA

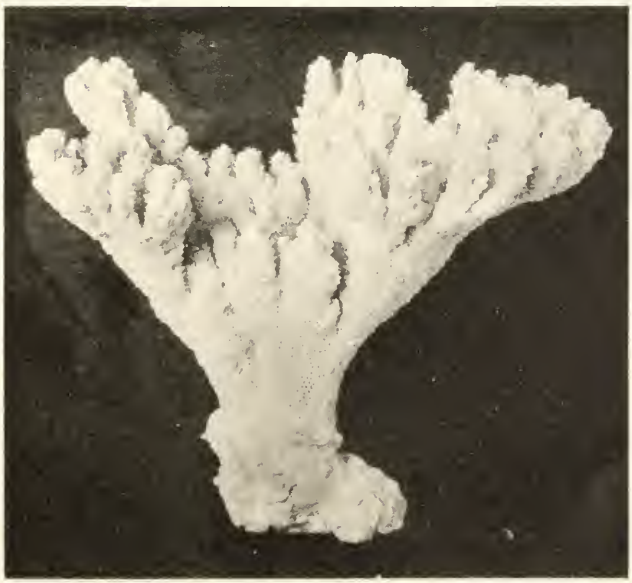
HELIOTYPE CO. BOSTON

PLATE 6.

Fig. 1. Pocillopora diomedeae, sp. nov., p. 65 General view of a bifurcated branch, natural size.

Fig. 2. Acropora mangarevensis, sp. nov., p. 68. Upright view of a corallum, $\frac{1}{3}$ natural size.

1



2

FIG. 1. POCILLOPORA DIOMEDEAE.

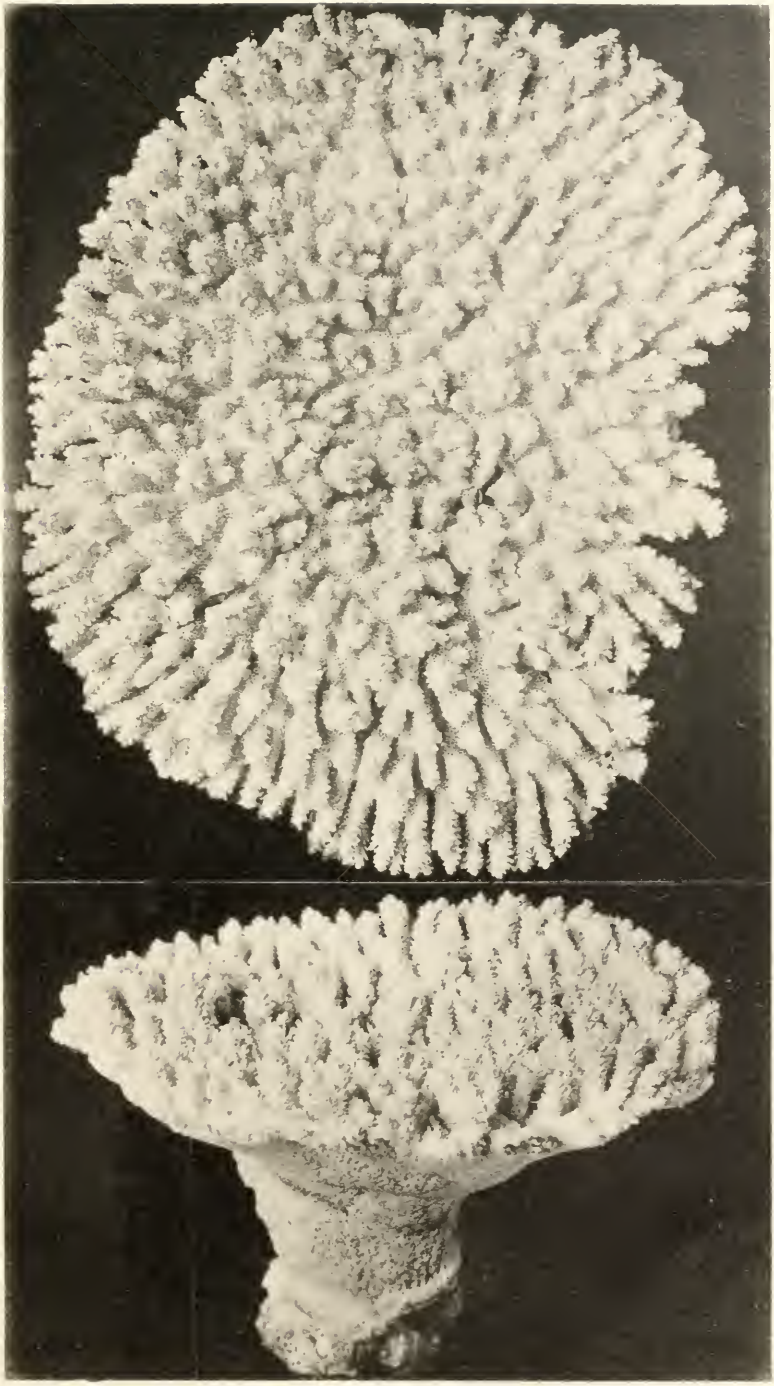
FIG. 2. ACROPORA MANGAREVENSIS.

HELIOTYPE CO., BOSTON.

PLATE 7.

Acropora diomedeae, sp. nov., p. 69.

FIG. 1. Upper surface of corallum, $\frac{1}{2}$ natural size; fig. 1*a*, upright view of corallum, $\frac{1}{2}$ natural size.



1

1a

ACROPORA DIGITATAE.

HELIOTYPE CO. BOSTON.

PLATE 8.

Fig. 1. Acropora mangarevensis, sp. nov., p. 68. A branch, × 2.
Figs. 2, 3. Acropora diomedeae, sp. nov., p. 69. Two branches, each × 2.

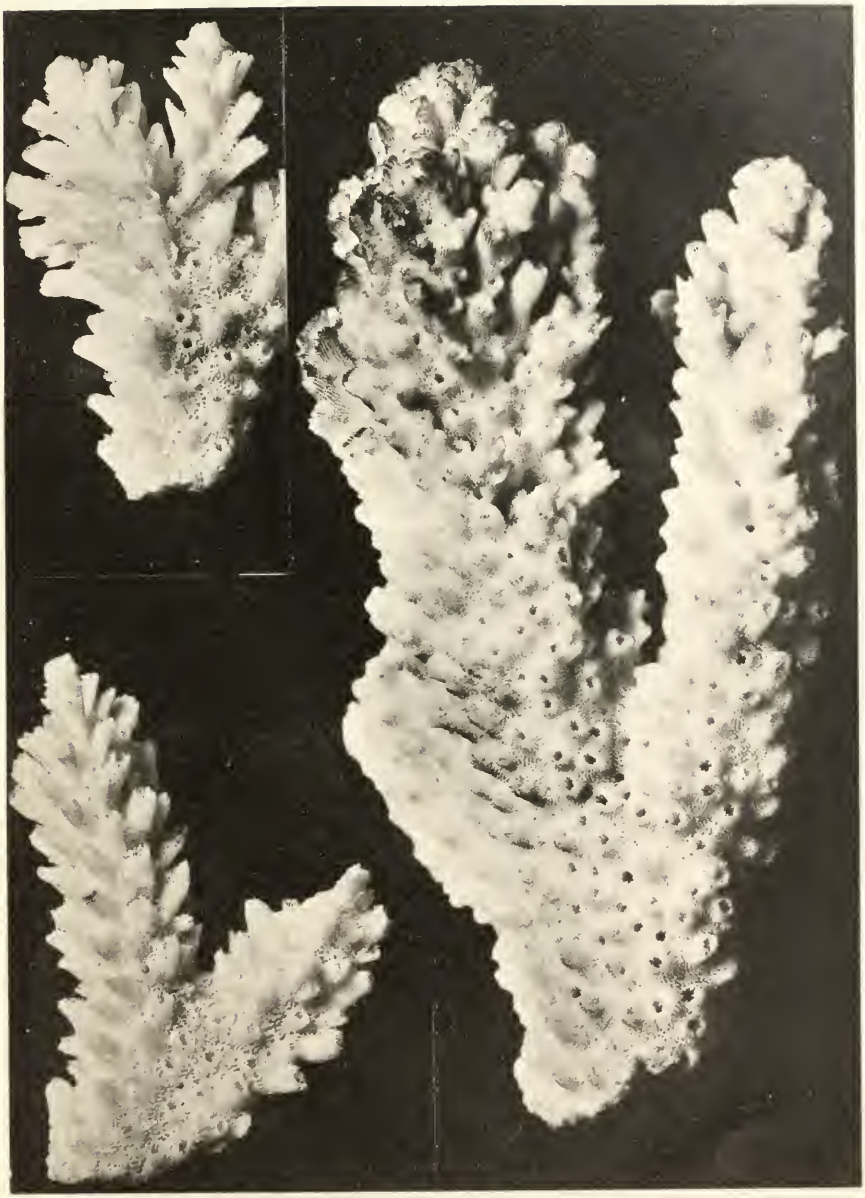


FIG. 1. ACROPORA MAGARENSIS.

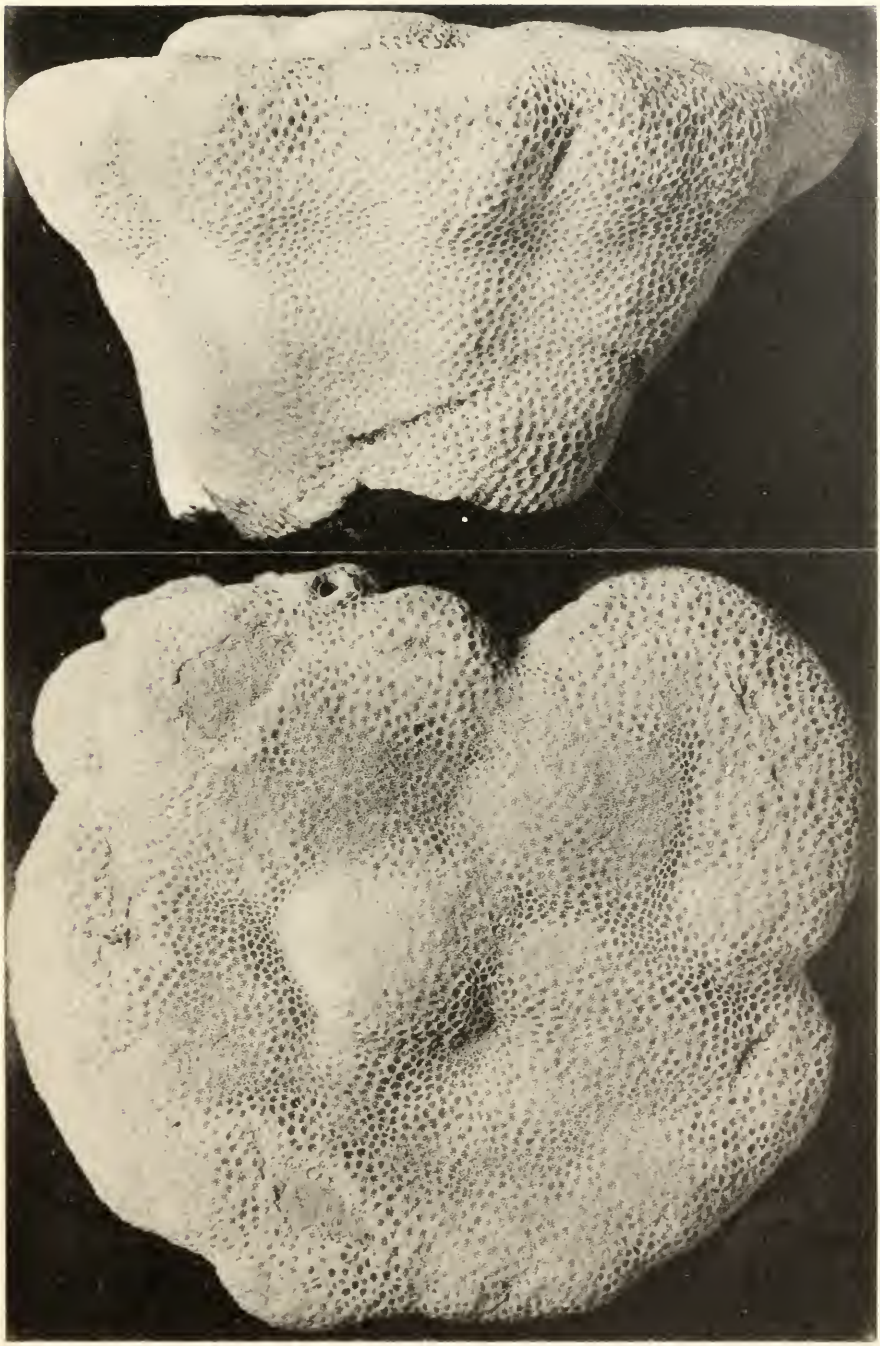
FIGS. 2, 3. ACROPORA DIOMEDEAE.

HELIOTYPE CO. BOSTON.

PLATE 9.

Porites paschalensis, sp. nov., p. 71.

Fig. 1. Upright view of corallum; fig. 2, upper surface, each natural size.



1

1a

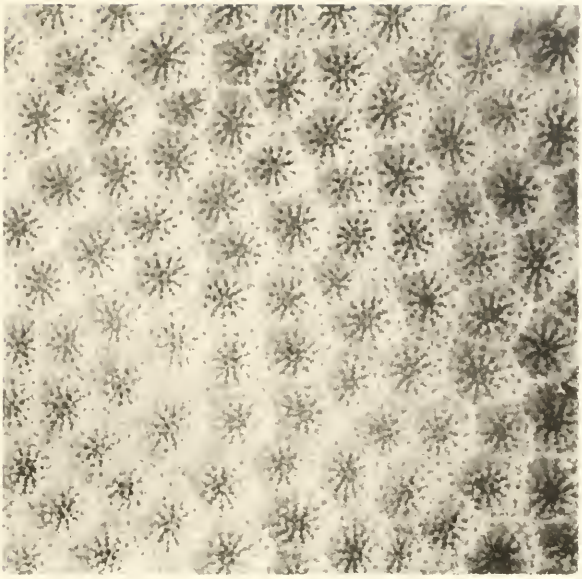
PORITES PASCHALENSIS.

PHOTOTYPE CO. BOSTON.

PLATE 10.

Porites paschalensis, sp. nov., p. 71.

FIG. 1. Calices on the side of the corallum; fig. 2, calices of a portion of the upper surface, each enlarged about 6 times.



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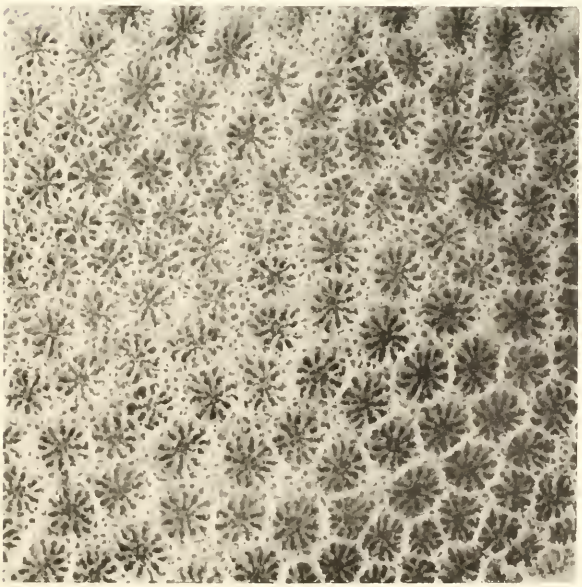

1a

PORITES PASCHALENSIS.

HELIOTYPE CO., BOSTON.

Bulletin of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. L. No. 4.

REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, TO MARCH, 1905, LIEUT. COMMANDER L. M. GARRETT, U. S. N., COMMANDING.

VII.

SHARKS' TEETH AND CETACEAN BONES.

By C. R. Eastman.

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With Four Plates.

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No. 4. — *Reports on the Scientific Results of the Expedition to the Eastern Tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross" from October*, 1904, *to March*, 1905, Lieut. Commander L. M. Garrett, U. S. N., Commanding.

VII.

Sharks' Teeth and Cetacean Bones. By C. R. Eastman.

One of the most interesting results of deep-sea dredging in the Pacific is the information that has been gained concerning the distribution of sharks' teeth and Cetacean bones over wide areas of the ocean floor, where, owing to the inappreciable amount of deposition away from the land, it happens that remains of extinct species have lain on the bottom unburied, and are found commingled with those belonging to the modern fauna. Material has now been collected in sufficient abundance, and over sufficiently wide tracts, to acquaint us in the first place with the general facts of distribution, and secondly to furnish data of comparison between fossil and recent forms. A third line of inquiry, which at present can only be suggested, but may possibly be pursued with increasing wealth of material, would be a study of the structural modifications which the auditory organs of Cetaceans have undergone since Tertiary times as the result of adaptation to a purely aquatic habitat.

We may take up first the question of geographical distribution. The most general conclusions that can be drawn from the results of dredging by the "Challenger" Expedition in 1875, and the two "Albatross" Expeditions of recent years (1899–1900 and 1904–1905), are these: —

1. Teeth of Lamnidae and Carchariidae occur in all parts of the Pacific, but are much more plentiful in southern tropical regions than elsewhere.

2. Cetacean ear-bones are found only exceptionally north of the equator, but are abundant south of it, especially between parallels 10° and 40° of south latitude.

3. Amongst Cetacean remains, those belonging to dolphins and Ziphioids are the most common, and most widely distributed; those belonging to whalebone whales (rorquals) are unknown north of parallel 32° of south latitude; and no indication of large sperm whales has been found in any part of the Pacific, not even in those regions now frequented by Physeteridae.

4. On the last "Albatross" Expedition (1904–1905) the largest hauls of sharks' teeth and Cetacean bones were made at stations lying within so-called barren regions, that is to say, areas far removed from the land, beyond the reach of telluric food-supply, and characterized by a most meagre pelagic fauna. The extent of these regions is sometimes such as to constitute veritable deathtraps, comparable to deserts on the land, for marine vertebrates that happen to have strayed therein. Thus, it is a significant fact that 70 per cent of the entire amount of material obtained during the last cruise of the "Albatross" was dredged from within what Mr. Agassiz has termed the barren area.[1]

One may judge of the extensiveness and variety of the evidence upon which the above generalizations repose from the following brief summary of results of the three expeditions contributing to it. The trans-Pacific cruise of the "Challenger" proceeded eastward from Yokohama to the meridian of 155° W, thence due south to Hawaii, to Tahiti, thence southeastward to the meridian of 130° W, and thence about due east to Valparaiso. Over a dozen stations are distributed along this route from which vertebrate remains were obtained in greater or lesser abundance, the percentage of fish, however, greatly predominating over mammalian. With the exception of two fragments, all the Cetacean bones were derived from red clays and Radiolarian oozes; and as stated by Dr. Murray,[2] none such were observed in any of the terrigenous deposits or calcareous oozes.

[1] The barren area of the Eastern Pacific is thus described by Mr. A. Agassiz in his General Report of the Eastern Pacific Expedition (Mem. Mus. Comp. Zoöl. 1906, **33**, p. 11):

The extensive barren area of the Eastern Pacific is situated a considerable distance from land. It is bounded on the north by the curve indicating the position of — h on Pl. 3c, and it is out of the track of great oceanic currents. Similar but less extensive barren tracts have been indicated by the trawling of the "Albatross" Tropical Expedition, and by those of the "Challenger" in the Central Pacific, and in the line from the Paumotos to Valparaiso. All these areas are at a distance from land, where no food comes from telluric sources owing to the steep continental slopes of the adjoining continents.

[2] Murray, J., Report on Deep-Sea Deposits. Scient. Results Chall. Exped. 1891, p. 270.

The same author also makes the following statement regarding the sharks' teeth observed during the "Challenger" Expedition:[1]

> The distribution of the sharks' teeth in the deposits is similar to that of the bones of Cetaceans, although they were dredged more frequently. They are most abundant in the red clay areas far removed from land, and especially in those of the central South Pacific; they were less frequently taken in the organic oozes of the deep sea, and only in one or two instances in the terrigenous deposits surrounding continental or other land. It seems undoubted that many of the teeth of sharks and the bones of the Ziphioid whales belong to Tertiary and extinct species.

These results are expressed numerically in the subjoined table, in which are recorded the position, depth, and bottom characters of all "Challenger" stations in the Pacific where sharks' teeth and Cetacean bones were obtained. At various other stations not included in this list, on the run from Hawaii to Peru, a few small teeth and otoliths of indeterminable fishes were brought up. Otoliths, on account of their dense structure and different chemical composition, are less readily destructible than other bones of Teleost fishes. Only in three or four instances were any piscine remains, other than otoliths and teeth, observed in all the deposits examined by the "Challenger" naturalists.

LIST OF "CHALLENGER" STATIONS YIELDING VERTEBRATE REMAINS.

Station Number.	Depth, Fathoms.	Position.		Nature of Bottom.	Number of Specimens.	
		Latitude.	Longitude.		Sharks.	Cetacea.
		° ′	° ′			
237	1875	34 37 N.	140 32 E.	Blue mud.	Several.	0
241	2300	35 41 N.	157 42 E.	Red clay.	1	0
244	2900	35 22 N.	169 53 E.	Red clay.	1	0
248	2900	37 41 N.	177 04 W.	Red clay.	1	0
252	2740	37 52 N.	160 17 W.	Red clay.	5	0
256	2950	30 22 N.	154 56 W.	Red clay.	9	0
274	2750	7 25 S.	152 15 W.	Reddish br. Radiolarian ooze.	Numerous.	13
276	2350	13 28 S.	149 30 W.	Red clay.	250	16+
281	2385	22 21 S.	150 17 W.	Red clay.	116	9
285	2375	32 36 S.	137 43 W.	Red clay.	1,500	50+
286	2335	33 29 S.	133 22 W.	Red clay.	350	90+
289	2550	39 41 S.	131 23 W.	Red clay.	1	5
293	2025	39 04 S.	105 05 W.	Brown Globigerina ooze.	2	1
299	2160	33 31 S.	74 43 W.	Blue mud.	0	1
					2,236+	185+

[1] *Loc. cit.*, p 276.

The second expedition to obtain vertebrate remains from deep-sea dredgings in the Pacific was the "Albatross" of 1899–1900. Its initial line from San Francisco to Tahiti converges toward that run by the "Challenger" from Hawaii to the same island; thence the course lay westward to the Fiji Islands, and thence in a general northwesterly direction to Japan. Between California and Tahiti eleven deep-sea dredgings were made by the "Albatross," four of which yielded vertebrate remains. During the remainder of the voyage three deep-sea hauls were made, only one of which (at Station 183, between Cook Islands and Tonga) yielded such remains. The discovery of Cetacean bones by this Expedition at Stations 2, 13, and 17 is interesting, these being the only instances in which this class of remains has been found north of the equator in any ocean.[1] Dolphins, Ziphioids and the pygmy sperm whale (Kogia) were included amongst the number. The nature and amount of material, together with indications of the depth and bottom characters are given for the several stations along this cruise in the following table.[2]

List of "Albatross" Stations Yielding Vertebrate Remains.

Station Number.	Depth, Fathoms.	Position.		Nature of Bottom.	Number of Specimens.	
		Latitude.	Longitude.		Sharks.	Cetacea.
		° ′	° ′			
2	2368	28 23 N.	126 57 W.	Red clay.	153	15
13	2690	9 57 N.	137 47 W.	Red clay.	58	7
17	2463	0 50 N.	137 54 W.	Globiger. ooze.	1	0
173	2440	18 55 S.	146 32 W.	Red clay.	6	0
183	2472	19 04 S.	167 41 W.	Red clay.	1	0
					219	22

[1] This statement should perhaps be qualified so as to exclude recent burials in deposits now forming along the coasts of continents. Bones of the Manatee, for example, were dredged by Pourtales as early as 1868 at depths between 100 and 400 fathoms off the coast of Florida. These bones are externally much corroded, and their substance has been transformed into an amorphous mass of calcite. Mention of them will be found in L. F. de Pourtales's contributions to the Fauna of the Gulf Stream at great depths. Bull Mus. Com. Zoöl., 1869, **1**, p. 123.

[2] Descriptions of this material have been published as follows: *Agassiz, A.*, Preliminary Report and List of Stations, with remarks on the Deep-Sea Deposits by Sir John Murray. Mem. Mus. Comp. Zoöl., 1902, **26**, p. 1–114. *Eastman, C. R.*, Sharks' Teeth and Cetacean Bones from the Red Clay of the Tropical Pacific. *Ibid.*, 1903, p. 179–191.

The next and most recent supply of material was furnished by the "Albatross" Expedition of 1904–1905. The general course of this cruise may be compared to the letter W, the base resting upon Manga Reva and Easter Island, and the three upper points touching at Acapulco, the Galapagos and Callao. In addition, a shorter series of zigzags were run between Panama on the north, and Callao on the south. These routes are all indicated on the accompanying chart (Pl. 3), as are also the limits of the extensive barren area described by Mr. Agassiz. It is noteworthy that the stations from which the largest individual hauls were made lie in about the middle of this belt, the greater plentifulness of remains suggesting that creatures here perished in larger numbers than the general average elsewhere, in consequence of the prevailing starvation diet. All of the remains collected by this Expedition showed a lighter encrustation of manganese as compared with those obtained by previous dredgings. Some of the Ziphioid ear-bones presented a remarkably fresh appearance, implying recent burial; amongst sharks' teeth on the other hand, the root, dentine, and all tissues except the enamel were invariably dissolved away. That many of these specimens have remained unburied on the ocean floor since late Tertiary times is rendered probable by the fact of their belonging to extinct species. The following tabulation of results may be compared with those given above for previous Expeditions.

List of "Albatross" Stations (1904–05) Yielding Vertebrate Remains.

Station Number.	Depth, Fathoms.	Position.		Nature of Botton.	Number of Specimens.	
		Latitude S.	Longitude W.		Sharks.	Cetacea.
		° ′	° ′			
4656	2222	6 54.6	83 34.3	Fine gn. M.	10	3
4658	2370	8 29.5	85 35.6	Fine gn. M., Rad. Oz.	15	1
4666	2600	11 55.5	84 20.3	Lt. gray ooze.	0	5+
4676	2714	14 28.9	81 24	Fine dk. br. ooze.	0	4
4685	2205	21 36.2	94 56	Dark brown clay.	73	6
4693	1142	26 30.1	105 45.2	Rocky.	?	?
4695	2020	25 22.4	107 45	Fine lt. br. ooze.	2	0
4701	2265	19 11.5	102 24	Dk. br. choc. clay.	8	2
4709	2035	10 15.2	95 40.8	Lt. gr. Glob. ooze.	1	12+
4711	2240	7 47.5	94 5.5	Lt. gr. Glob. ooze.	2	4+
4721	2084	8 7.5	104 10.5	Lt. br. Glob. ooze.	0	7
4732	2012	16 32.5	119 59	Lt. gy. Glob. ooze.	1	0
4736	2289	19 0.4	125 5.4	Dk. br. choc. mud.	20	4
4740	2422	9 2.1	123 20 1	Dk. gy. Glob. ooze.	1	3
					133	51+

From the foregoing table it will appear that out of a total of thirteen stations from which sharks' teeth and Cetacean bones were obtained, remains of the former to the number of 133 were dredged from ten stations, and of the latter to the number of 51 from eleven stations. Three stations, all lying outside the barren area as defined by Mr. Agassiz (Nos. 4666, 4676, 4721), afforded indications of Cetaceans alone; and two stations, both lying within the barren area (Nos. 4695 and 4732) yielded sharks' teeth without admixture of Cetacean bones. Possibly this last circumstance may be purely fortuitous; or again, on the other hand, it may suggest that whales and dolphins were on the whole less precipitate than sharks in venturing upon a tract of greatly diminished food supply. If this were so, one might expect the gregarious habits of Cetaceans to have had something to do with their avoidance of a barren area. Stragglers might wander in, but the tendency of herds would be to confine their range to areas affording a sufficient food supply.

General Summary of Results by Stations.

Station 4656, depth 2222 fathoms. — There were brought up by the dredge from the bottom at this station 10 sharks' teeth, amongst which 4 are recognizable as belonging to the genus Lamna, 1 to Oxyrhina, 1 to Carcharodon, this last being a fine specimen (Plate **2**, Fig. 21), and the rest merely fragments. The Cetacean material consisted of 1 tympanic bulla of Hyperoodon, 1 periotic of Kogia or some very similar form, and one indeterminate long and slender bone. Most of these remains are but slightly encrusted with manganese.

Station 4658, depth 2370 fathoms. — 4 teeth of Oxyrhina, 9 Lamna, 2 nondescript fragments; also 1 Delphinoid tympanic. Manganese coating very slight.

Station 4666, depth 2600 fathoms. — No fish remains; 4 excellently preserved ear-bones of Hyperoodon, one having the tympanic still fused with the periotic; also 1 heavily encrusted Delphinoid tympanic, and several corroded osseous fragments.

Station 4676, depth 2714 fathoms. — No fish remains; 3 rather heavily encrusted ear-bones of Hyperoodon (Plate **3**, Fig. 36), and 1 unrecognizable fragment.

Station 4685, depth 2205 fathoms. — This station, which lies within the barren area, is remarkable for having furnished a larger number of vertebrate remains than any other during the cruise, and with them were brought up one and one-half tons of manganese nodules. There are in all

73 sharks' teeth, 5 of which belong to Carcharodon, the rest to Lamna and Oxyrhina. Some of the teeth are embedded in nodular masses; none have the crowns heavily encrusted, but the majority have dark brown clay adhering to them. Cetaceans are represented by 5 Delphinoid ear-bones; the tympano-periotic of one individual consists of a single piece.

Station 4693, depth 1142 fathoms. — According to the published record of "Albatross" dredging stations, in the *General Report of the Expedition*,[1] sharks' teeth and Cetacean bones came up in the trawl at this locality. None such are contained, however, in the collection submitted for examination, the only specimen marked with this station number being a well preserved tergum of Lepas.

Station 4695, depth 2020 fathoms. — The vertebrate remains dredged at this point are confined to two small and tolerably fresh-looking Oxyrhina teeth.

Station 4701, depth 2265 fathoms. — 8 sharks' teeth, including 1 large and beautifully preserved Carcharodon, wholly unencrusted, also 1 large and 6 smaller Oxyrhina teeth, very lightly coated; 2 Delphinoid ear-bones, likewise with very little coating.

Station 4709, depth 2035 fathoms. — 2 small fresh-looking Lamna teeth; 2 heavily encrusted ear-bones of Hyperoodon, one indeterminate elongate bone, and several smaller fragments; also 9 lightly coated Delphinoid ear-bones.

Station 4711, depth 2240 fathoms. — Two very slightly encrusted Lamna teeth; 2 Delphinoid ear-bones, one being a large, very heavily encrusted tympanic, the other a moderately coated tympano-periotic; also a number of corroded fragments, all charged with manganese, and betraying only obscure indications of organic origin.

Station 4721, depth 2084 fathoms. — No fish remains; 4 Delphinoid ear-bones, and 3 of Kogia or some very similar form.

Station 4732, depth 2084 fathoms. — No fish remains; 4 Delphinoid tympani, 3 specimens of Kogia, one having the tympanic and periotic fused, all lightly coated with manganese.

Station 4732, depth, 2012 fathoms. One splendidly preserved Carcharodon crown without manganese coating, but with several worm-tubes adhering to it (Plate **2**, Fig. 20); no Cetacean bones. This and the next following station lie within the barren area.

Station 4736, depth 2289 fathoms. 1 small Carcharodon, 6 Oxyrhina, 13 large-sized Lamna teeth, all stained dark brown and very thinly coated with manganese; 3 Delphinoid tympani, and 1 much decayed

[1] Mem. Mus. Comp. Zoöl., 1906, **33**, p. 44.

Cetacean tooth corresponding in size to Hyperoodon, more or less chocolate-colored.

Station 4740, depth 2422 fathoms. — 1 splendidly preserved Carcharodon tooth, shown in Pl. **2**, Fig. 23, from the external face; 1 Kogia, and 2 Delphinoid ear-bones.

SYSTEMATIC ACCOUNT OF THE REMAINS.

Elasmobranchii.

(Plate 2.)

The collection contains one hundred and thirty-three sharks' teeth, all referable to three genera of Lamnidae, Lamna, Oxyrhina, and Carcharodon, named in order of their numerical abundance. None of the teeth are preserved in anything like their entirety. The dentine has been dissolved away, leaving only a thin shell of enamel, and the loss of the root and lateral denticles (in all cases where the latter were formerly present) is a serious hindrance to accurate determination. It has not been possible to recognize heretofore more than two species with certainty, *Oxyrhina crassa* Ag., and *Carcharodon megalodon* Ag., both of which are widely distributed in Tertiary formations, but unknown in the modern fauna. To this number may now be added with some degree of confidence a third species, which we take to be identical with *Carcharodon lanciformis* Gibbes. These teeth are characterized by having very much flattened crowns, broadly triangular in form, with acutely pointed apex and finely serrated lateral margins (Plate **2**, Figs. 19–22). They are readily distinguished from *C. megalodon* by their great lateral compression and usually smaller size. Their separation from the existing *C. rondeletii* is less easy, differential characters being found in the presence or absence of lateral denticles, and the form of the coronal apex. These three species which we are able to recognize with tolerable certainty in deep-sea deposits, namely, *Oxyrhina crassa*, *Carcharodon megalodon*, and *C. lanciformis*, likewise occur associated with one another in the Phosphate beds of South Carolina and other Tertiary localities.

Illustrations of a selected series of sharks' teeth from the Eastern Tropical Pacific are shown in Plate **2** of this Bulletin. As the features presented by the newly acquired shark material are essentially the same as have already been described at sufficient length in the "Challenger" and "Albatross" Reports, no good purpose would be served by mere repetition of details in the present paper. Contrariwise, the earlier Reports contain only a meagre account of Cetacean ear-bones,[1] hence we

[1] Some of the generic determinations in the previous Reports are clearly open to question. In particular, Kogia and Globicephalus have been confused.

shall do well at this time to devote a larger share of attention to the deep-sea Mammalian remains.

Cetacea.

Cetacean remains were dredged in greater abundance, and from more numerous localities, during the "Albatross" Expedition of 1904–1905 than on the previous cruise of this vessel in the tropical Pacific. The Expedition of 1904–1905 was also successful in bringing up Cetacean teeth for the first time from great depths, two such being contained in the collection. On the other hand, no indications of Mystacocete whales were observed, and it is regarded as quite remarkable that neither the "Albatross" nor "Challenger" Expeditions encountered any traces of the great sperm whale (*Physeter macrocephalus*), notwithstanding that numerous hauls were made within the usual habitat of this animal. Remains of the closely allied pygmy sperm whale, however, occurred at several localities. Ear-bones of Dolphins constitute the greater part of the material, as might be expected, although apparently not more than one or two species are represented. Next in order of abundance are the ear-bones of Hyperoodon, whose habits are gregarious. Several specimens belonging to this genus are scarcely discolored, and present an exceedingly fresh appearance.

The state of preservation of the remains as a whole differs in no respect from that which has been previously observed, and is described by Professor Sir William Turner in following language:[1]

> The preservation of the ear-bones and of the fragments of the beaks of ziphioid whales is accounted for by the extreme density of these portions of the skeleton. Some of the bones were in a much better state of preservation than others. In some the manganese coating was extremely thin, and but little had entered into the Haversian canals and lacunae, so that a fractured surface was greyish-white (Mr. Murray's Pl. X. Figs. 1*a*, 1*b*, 2*a*, 4*a*). Others again were not only thickly encrusted with the mineral, but the Haversian canals and lacunae were infiltrated with it, so that a fractured surface was dark brown or black, and the bones were extremely brittle. The chemical composition of these bones was thus entirely altered, and this was more especially the case with the fragments of the flat bones, and others of a more porous texture which formed the nuclei of so many of the manganese and iron nodules. . . . It is to be noted that the bones obtained did not present any evidence of having been rolled or rubbed They had evidently rested quietly in the spots where they had been deposited, and in many cases the tympanic and petrous bones were still attached to each other, although they could be separated by the exercise of but little force.

[1] Turner, W., Report on Bones of the Cetacea. Sci. Results Chall. Exped. Zoöl vol. 1, 1880, p. 41.

This last observation with respect to fusion between the tympanic and periotic applies also to material obtained by the "Albatross" Expedition, and it is interesting to note that some specimens still have the stapes preserved in its natural position. This is the more remarkable in view of the fact that the stapes is not anchylosed, but firmly held in place by muscular attachment within its proper aperture, the *fenestra ovalis*. We will return to a description of the different parts further on.

The question is apposite whether any certain identifications can be made between these deep-sea remains and fossil or recent Cetaceans. In the case of the "Albatross" material it must be acknowledged that no specimens can be positively referred to extant species. The differences they present are all of minor nature, and yet sufficient in the aggregate to make it extremely hazardous to pronounce in favor of absolute identity. One may safely affirm that the bones here referred to Kogia and Hyperoodon differ specifically from *K. breviceps* and *H. rostratus*, but as for undertaking comparisons with other existing representatives of these genera, there is not only great lack of material, but the published descriptions and illustrations are singularly inadequate. Confusion exists as to what species should be properly retained in the former genus, and the second known species of Hyperoodon, *H. planifrons* rests upon the evidence of a solitary water- and pebble-worn skull. On the other hand, a number of well preserved fossil ear-bones of Hyperoodon are available for comparison, which will be referred to later, but none have hitherto been found of the genus Kogia. The range of comparison amongst fossil Delphinoid remains is limited, since most of the extinct forms belong to the Platanistid division, and hence are not properly classed with true Dolphins. The affinities of the deep-sea ear-bones seem to be rather with the Delphinidae proper, and some of them show considerable resemblance with those of the existing *Delphinus delphis* Linné (*cf.* Plate **3**, Figs. 30–32).

The conclusions just stated all have reference to the "Albatross" material. Turning now to that obtained by the "Challenger," we find identifications made with four existing species, whose remains, however, were all dredged from more southerly areas than were visited by the "Albatross." The greater number of "Challenger" ear-bones are believed by Professor Sir William Turner to belong to extinct forms, his remarks on this subject being as follows :[1]

> The sharks' teeth belonged to the genera Carcharodon, Oxyrhina, and Lamna, and are to be referred to no species, so far as we know, now living. The question

[1] *Loc. cit.*, p. 42.

therefore naturally arises, Are the cetacean remains associated with them on the floor of the ocean, the bones of existing or extinct forms? Of the resemblance of the greater number of these bones, more especially the tympanic bullae, to existing genera, I have given a number of examples, and have occasionally had to point out how closely some of them correspond with existing species, so that they may be referred to them. But whilst these may be the bones of species still extant, there are others which present greater difficulties in the identification, so that, like the sharks, they may have belonged to animals which had lived in a previous geological epoch.

Neither the authority quoted, nor others who have occupied themselves with the study of Cetacean ear-bones, speak of having undertaken comparisons between deep-sea and fossil material; and although the general anatomy and taxonomic characters of these organs are subjects of great importance, and afford a promising field of inquiry, it cannot be said that they have received the attention they deserve on the part of either palaeontologists or cetologists. Insufficiency of material for comparison is of course largely responsible for this neglect: or if not actually insufficient, it is at least difficult to obtain a first-hand acquaintance with the fossil supply, owing to its scattered distribution in New and Old World museums. Another requisite involving some experience is a nice perception of the degrees of difference or resemblance which fossil and recent material offer on comparison with that dredged from the ocean bottom. It thus appears that the subject is well hedged about with difficulties. It is always advisable, however, to recognize the natural limitations of whatever problem one may be engaged upon, and to refrain from striving after greater accuracy than the nature of the subject permits.

In view of the circumstances just mentioned, we cannot attempt more than a recapitulation of the principal characters of Cetacean ear-bones, and an inquiry into the more general relations between Tertiary species and those brought to light by the "Albatross" dredgings. Before entering upon this discussion it may not be inadvisable to give a brief account of fossil ear-bones, and also to describe a single recent example for the purpose of making our comparative observations more intelligible. This procedure would seem to be necessary to an understanding of various minutiae, the importance of which for systematic purposes has been overlooked. We will consider these different points in order.

Ear-bones of Fossil Cetaceans.

Ear-bones of fossil whales appear to have been first recognized as such by Baron J. von Hüpsch, an amateur collector of Cologne, who described

in 1794 several specimens pertaining to the Balaenidae from the Antwerp Crag, and records having some in his possession from America as well.[1] Thereafter, remains of this sort attracted but little attention on the part of naturalists, not even excepting Cuvier, until the late P. J. Van Beneden began his important researches on recent and fossil Cetacea during the third decade of the last century. Indeed, one of the earliest papers of the Belgian cetologist relates to the identification of rorquals from the Antwerp Crag by means of a comparative study of ear-bones:[2] and another, published the same year, has for its title: "Observations sur les caractères specifiques des grands Cetacés, tirés de la conformation de l'oreille osseuse."[3] During the early forties, fossil ear-bones were discovered in the Red Crag of Suffolk, and on being shown by agricultural chemists to contain a large proportion of lime phosphates, the deposits containing them were actively exploited. Owen refers to the economic importance of the strata, estimating that many thousand pounds annually of the superphosphates were derived from its concretions, and that "thousands of cubic acres of earlier strata must have been broken up to furnish the Cetacean nodules of the 'Red Crag.' This is a striking instance of the profitable results of a seemingly most unpromising discovery in pure science — the determination of what in 1840 was regarded as a rare, unique, and most problematical British fossil."[4]

Although our knowledge of British fossil Cetacea was largely increased by Owen, his attention was only incidentally engaged by ear-bones, and it is to the later investigations of Lankester, Flower, and Lydekker[5] that we owe our chief information in regard to English material. Casual references occur to this class of remains in the writings of American palaeontologists, but no attempt has thus far been made to collect the results of their scattered observations. Indeed, instances are not wanting where these organs have been entirely overlooked, although

[1] Beschreibung einer neu entdeckten versteinerten Theile grosser Seethieren. Der Naturforscher, 3 Stuck, p. 178–183, 1774. The date of publication is also given as 1794 by Van Beneden and Gervais in their work on Cetaceans, one of their species being dedicated to the Baron, "qui a bien connu ces ossements fossiles à la fin du siècle dernier."

[2] Mention du gîte important d'Anvers. Bull. Acad. Roy. Belg., 1835, **2**, p. 67.

[3] Comptes-rendus 1835, **3**, p. 401.

[4] Palaeontology, p. 343, Edinburgh, 1860. Hist. Brit. Foss. Mammals, p. 536.

[5] Complete references are given in Dr. Lydekker's paper on Cetacea of the Suffolk Crag (Quart. Journ. Geol. Soc. (1887), **43**, p. 7–18), and in his Supplement to the Catalogue of Fossil Mammals in the British Museum (1887).

preserved in natural association with the skull, a conspicuous example being the type of *Lophocetus calvertensis* (Harlan). Thus it appears that the subject is eminently worthy of further cultivation, and one is gratified to note that within the last few years signs of renewed interest have become manifest in the writings of several continental palaeontologists, notably Abel,[1] Dal Piaz,[2] and Flot.[3]

Any comparative study of the bones related to the organ of hearing in Cetaceans, whether fossil or recent, must take careful account of certain minutiae, the nature of which may best be explained by describing these parts in a typical example, such as is furnished by the recent *Delphinapterus leucas*. The description here offered will be found to correspond closely with the accounts that have recently been given of the auditory organs of the Porpoise by Beauregard,[4] Denker, and Boenninghaus, whose papers contain a mass of valuable information, both anatomical and physiological, besides abundant references to the literature. We have also adopted the same designations of parts as employed by these authors, and have arranged and lettered the accompanying text figures so as to correspond with the series of *Phocaena communis* given by the last mentioned. The aspects selected for illustration are obtained by rotating the specimen upon its axis through successive quadrants, and then turning it end for end. There are thus shown in order the external, superior, internal, and inferior surfaces, and finally the two end-views.

General Characters of Cetacean Ear-Bones as Illustrated by Delphinapterus.

(Text-figures A–F.)

In the genus under consideration, as in Delphinoids generally with the possible exception of Platanista, the united tympanic and periotic

[1] Abel, O., Untersuchungen über die fossilen Platanistiden des Wiener Beckens. Denkschr. k. Akad. Wissensch. (1900), **68**, p. 839–874. Les dauphins longirostres du Boldérien des environs d'Anvers. Mém. Mus. Roy. d'Hist. Nat. Belg. Année 1901, p. 1–95. Part II., *ibid.*, 1902. Eine Stammtype der Delphiniden aus dem Miocän der Halbinsel Taman. Jahrb. k k. geol. Reichsanst. (1905), **55**, p. 375. Les Odontocètes du Boldérien d'Anvers. Mém. Mus. Roy. d'Hist. Nat. Belg. Année 1905, p. 1–155.

[2] Dal Piaz, G., Sugli avanzi di Cyrtodelphis sulcatus dell' arenaria di Belluno. Palaeont. Ital. (1903), **9**, p. 187–219. Part II., *ibid.* (1905), **11**, p. 253–280.

[3] Flot, L., Note sur les Cetacés fossiles de l'Aquitaine. Bull. Soc. Géol. France (1896), **24**, p. 270–282.

[4] Beauregard, H., Recherches sur l'appareil auditif chez les mammifères.

has only a ligamentous connection with the surrounding bones of the skull, and hence readily becomes detached from the latter in maceration. The body of the tympanic corresponds to the bulla tympanica of various other Mammalia, that of the periotic, which somewhat resembles the figure 6 in form, to the petrous bone. Processes are developed by each by means of which the two elements are conjoined at either end, leaving a narrow longitudinal slit between them, known as the "tympano-periotic fissure." Although anchylosed in the adult, thus justifying the term of tympano-periotic, the two bones are easily separable in young individuals. During early stages, also, according to Boenninghaus,[1] these bones form almost an integral part of the periotic region of the cranium, and are oriented with their long axis parallel with the median line of the body, the spout-like aperture for the Eustachian canal being placed foremost. The elements soon become protruded downward, however, and a recess is formed for them on the side of the base of the cranium; owing to the more rapid increase in width of the hinder portion of the skull, the main axis of the tympano-periotic becomes shifted so as to be directed almost diagonally with reference to the longitudinal axis of the body. Notwithstanding this obliquity of position, it is customary to speak of the two extremities as anterior and posterior respectively, and of the lateral walls or "lips" of the bulla as external and internal. The latter bone is hollow, broad, rounded, and distinctly bilobed behind, pointed in front, and open above except for a short distance posteriorly where the process for attachment with the periotic forms an archway spanning over both lips. Immediately in front of this process is a somewhat crescentic opening for the external auditory meatus, closed in the living animal by the membrana tympani.

The periotic is an irregular bone, somewhat shorter than the tympanic; its central rounded portion or promontory, which encloses the cochlea, is very dense, and pierced by several openings. On the cerebral side is seen the large *meatus auditorius internus;* on the surface opposed to the tympanic cavity the *fenestra ovalis* (or *vestibuli*), which receives the stapes, and directly above it the aperture for the Fallopian canal; nearly in line with them below, and looking posteriorly, is the somewhat larger *fenestra rotunda*, otherwise known as the *fenestra*

Journ. Anat. Physiol. (1894), **30**, p. 366–413. Denker, A., Zur Anatomie des Gehörorgans der Cetacea. Anat. Hefte (1902), **19**, p. 423–448. Boenninghaus, G., Das Ohr des Zahnwales. Zool. Jahrb. Anat. (1904), **19**, p. 189–360.

[1] *Loc. cit.*, p. 225.

cochleae. We will now describe the different aspects of the subject selected for illustration, beginning with the external.

External face (Fig. A). — The most obvious feature of the outer lip (1) of the bulla ossea relates to the presence of certain processes along the superior margin. There is one at either extremity, termed respectively the *processus anterior* (3) and *proc. posterior* (4), whose function is to unite the tympanic and petrous (2) bodies in the manner already explained. These are the only points of contact where the two bodies are actually fused, and they are completely separated below by the

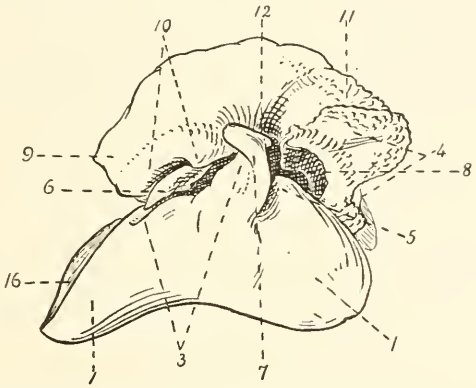

FIG. A. — Left tympano-periotic of the existing *Delphinapterus leucas* Pallas. External face, × ½.

The same numbers are used in Figs. A–F for the following parts: 1, Bulla tympanica (outer lip); 2, Petrosal; 3, Proc. ant. bullae; 4, Proc. post. bullae: 5, Proc. conicus bullae (= rudimentary inferior wall for external auditory meatus); 6, Proc. tubarius (= part of anterior process supporting so-called "accessory ossicle"); 7, Proc. sigmoideus (= rudimentary anterior wall of external auditory meatus); 8, Position of membrana tympani; 9, pointed anterior extremity of petrous body; 10, Proc. ant. petrosi; 11, Proc. post. (mastoideus) petrosi; 12, Hiatus epitympanicus; 13, Aptertura extern. aquaeductus vestibuli; 14, Apertura extern. aquaeductus cochleae; 15, Porus acusticus internus; 16, bulla tympanica (inner lip); 17, Fissura tympano-periotica; 18, Orificium (Hiatus) tympanicum; 19, Apertura tympanica canalis Eustachii; 20, Groove for the nervus facialis; 21, Fenestra cochleae.

tympano-periotic fissure (17). There are developed in the intermediate space between these processes two others, the more prominent of which is singularly formed, and receives the name of *proc. sigmoideus* (7). The smaller one closely adjoining it is of conical form, and provides a corresponding recess within the tympanic cavity immediately below the *porus acusticus*, or aperture in which the tympanic membrane is suspended. It is numbered 5 in figures A and E, and may be referred to

for short as the *processus conicus*. Beauregard terms it "apophyse conique postèrieure," Boenninghaus "processus medius." The conformation of the various parts just indicated is worthy of particular note since they furnish important diagnostic characters.

The anterior process is constricted off from the superior margin of the outer lip by a well-marked groove so as to form a slender tenon-like projection (6), which extends backward as far as the middle portion of the periotic. It is, indeed, partially concealed by the latter bone, with which it fuses after first becoming enlarged into a bulbous or knob-like "accessory ossicle," as it is called by Lydekker. This enlarged portion fits snugly into a corresponding cavity of the periotic, and is usually broken away with that bone, instead of with the tympanic, when the two are forcibly separated. Frequently it is lost in the process of fossilization or maceration, when its appropriate cavity is plainly visible in the periotic. It is to the tympanic, however, that the ossicle properly belongs; and since, according to Boenninghaus, its function is to support the Eustachian canal, it may be compared with the *processus tubarius tympanici* of the horse and sheep.

The posterior process (4) is confluent below with both lips of the bulla, is constricted in the middle, and has an enlarged and elongate upper portion or "head." This upper portion exhibits on the cerebral face a broad articular facette for union with a corresponding process of the periotic, and serves externally for the attachment of cartilage or connective tissue, by means of which the combined tympano-periotic is firmly held in place on the under side of the skull. The posterior process has a more open or fibrous structure than other parts of the element to which it belongs. This condition is not only visible externally, but is very conspicuously shown by the articular facette just mentioned. The coarse striation of this surface contrasts strongly with the smooth appearance of the corresponding parts in toothed whales, and is occasioned by a fan-shaped arrangement of bundles of osseous tissue. Spanning across both lips of the bulla near its hinder extremity, the posterior process extends forward so as to come very nearly, but not quite in contact with the processus sigmoideus. The three processes we have named, posterior, conicus and sigmoideus, enclose between them the rounded aperture across which is suspended the *membrana tympani* (8). The walls which they together take part in forming are interpreted by Boenninghaus as a rudimentary osseous external auditory meatus.

Superior face (Fig. B). — The more conspicuous body appearing from

this aspect is identifiable with the petrous bone of other mammals, and has the usual pointed anterior extremity (9). Immediately behind this is seen a tumid shelf-like projection which overhangs and partly conceals the anterior process of the bulla, together with its " accessory ossicle," being in fact slightly fused with the latter underneath. This projecting portion of the front margin is called the *processus anterior petrosi* (10); and underneath it passes in a longitudinal direction the tensor muscle of the tympanic. The hinder portion of the petrous body forms the posterior process (11), by which, as we have seen, the periotic and tympanic are principally held together. A portion at least of this structure is evidently equivalent to the *processus mastoideus petrosi* of other Mammals. About midway between the two processes referred to, a sinus occurs in the supero-external margin of the periotic which

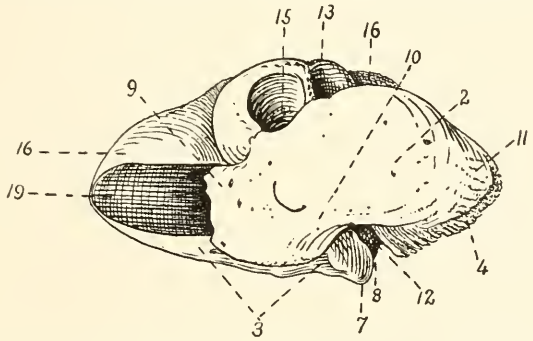

FIG. *B.* — Left tympano-periotic of the existing *Delphinapterus leucas* Pallas. Superior face, × ½.

affords ingress by means of an obliquely descending semicircular conduit (12) into the tympanic cavity. This passageway is named by Beauregard *ductus petro-tympanicus;* by Boenninghaus, who regards it as peculiar to Cetacea, it is called *hiatus epitympanicus.*

Cerebral or inner face (Fig. C). — Viewed from this position, the narrow inner lip (16) of the bulla appears uppermost in the figure (in reality it is lowermost), and immediately below this, yet separated from it by the continuous tympano-periotic fissure, is the rounded portion of the periotic which contains the cochlea. The windings of the scala may be readily followed, the outer wall being formed by the promontory, and the inner spirals appearing within the large funnel-shaped pit known as the *porus acusticus internus* (15), which gives passage for the acustico-facial nerve. In the present form, as indeed in most Delphinoids, the aperture

for the *nervus facialis* is confluent with the *porus acusticus* on that side of the periotic which is turned away from the tympanic, but it sometimes happens, as in Mesoplodon, that these openings are separated. The *nervus facialis* emerges on that side of the periotic which is turned toward the tympanic through a small round aperture (*apertura tympanica canalis Fallopiae*) which is continued backward in the form of a semi-enclosed canal (20). Two other openings are visible on the cerebral face of the periotic, placed one above the other in close proximity to the *porus acusticus*. The smaller of these communicates directly with the cochlear labyrinth, and is only separated from the external opening of the latter (*fenestra cochleae*) by a slight bridge. The name given to this smaller opening is *apertura externa aquaeductus cochleae* (14). The larger one above it is called from its communication with the scala vestibuli the *apertura externa aquaeductus vestibuli* (13). All of these openings vary more or less in form, size, and position amongst different genera, and hence require attentive examination.

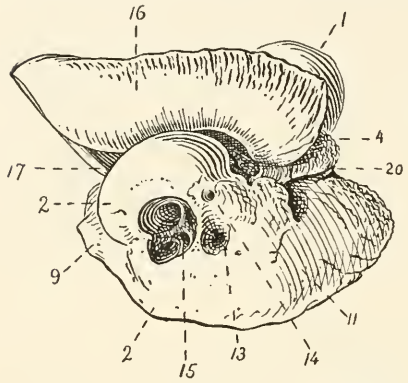

FIG. *C.* — Left tympano-periotic of the existing *Delphinapterus leucas* Pallas. Inner or cerebral face, inverted, × ½.

Inferior face (Fig. D). —Rotation through another quadrant of arc brings into view the lower surface of the bulla ossea. It is traversed longitudinally along its middle portion by a broad sulcus that gradually deepens posteriorly, thus forming an inner (16) and an outer (1) lip. The surface of the latter is smooth, that of the former very rough, the rugosity extending about half-way

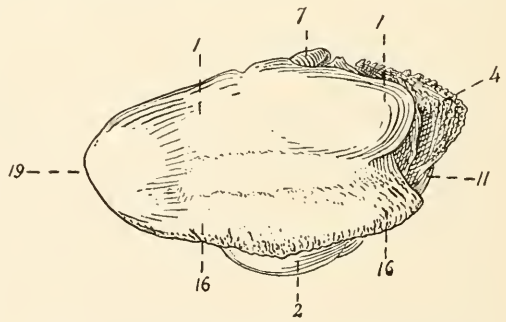

FIG. *D.* — Left tympano-periotic of the existing *Delphinapterus leucas* Pallas. Inferior face, × ½.

up the reflected inner wall of the bulla. The walls are thickest where the surface is rough, and thinnest over the smooth outer lip.

Posterior end (Fig. E). — Viewed from behind, the most marked features are the bilobed form of the bulla, the large size and spongy texture of the posterior processes (4, 11) of the tympanic and periotic, the continuity of the narrow tympano-periotic fissure (17), the large canal for the egress of the facial nerve already referred to (20), and the large opening in the posterior wall of the promontory known as the *fenestra cochleae* (21).

Anterior end (Fig. F). — Above is seen the obtuse forward extremity of the periotic, below the produced and spout-like termination of the Eustachian canal (19). The opening of the latter is not completely en-

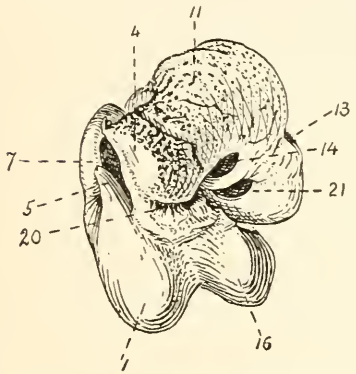

FIG. *E*. — Left tympano-periotic of *Delphinapterus leucas* Pallas. Posterior end, × ½.

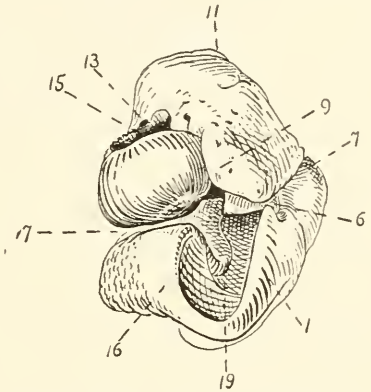

FIG. *F*. — Left tympano-periotic of *Delphinapterus leucas* Pallas. Anterior end, × ½.

closed, as in other Mammals, but drawn out into a long slit-like canal, which is confluent above the superior margin of the inner lip with the fissura tympano-periotica (17). A portion of the knob-like "accessory ossicle" (6) of the tympanic is plainly visible below the overhanging anterior process of the periotic (10).

Having now examined different aspects of the periphery, our next procedure would be to separate the two elements of the tympano-periotic, and observe those surfaces which are presented towards each other, and hence remain concealed when the bones are in natural apposition. These inner faces, however, are precisely the ones which have been oftenest figured and described in the case of fossil forms, and as regards the recent Delphinapterus, the general resemblance to Phocaena is such that the

same description will apply to both. We may therefore content ourselves with reproducing one of Denker's illustrations of the latter genus (Fig. G), and referring to his descriptions, as well as those by Beauregard and Boenninghaus, of its auditory organs. The modifications certain

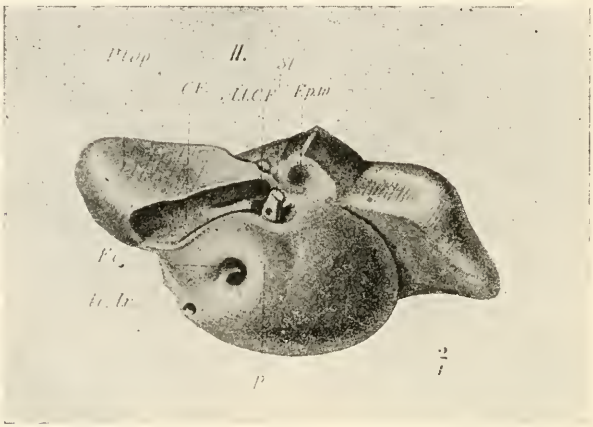

Fig. *G.* — Tympanic aspect of right periotic of *Phocaena communis* Linn. × ½ (after Denker). *A. t. C. F.*, Apertura tympanica canalis Fallopiae; *A. e. A. c.*, Apertura externa aquaeductus cochleae; *C. F.*, Semi-enclosed canal for the nervus facialis, with groove for the musc. stapedius; *F. c.*, Fenestra cochleae; *F. p. m.*, Pit for head of the hammer; *P.*, Promontory, or capsule containing the semicircular canals; *P. t. o. p.*, Processus tympanicus ossis petrosi; *St.*, Stapes, immovably seated in the fenestra ovalis, but not anchylosed with it by bony union.

parts have undergone for the better perception of sound waves transmitted through the walls of the skull are clearly pointed out by these authors.

Distinctive Characters of Cetacean Ear-Bones.

A brief recapitulation of the more general characteristics of Cetacean ear-bones is here given, by way of directing attention to those features which are available for the distinction of groups of greater or lesser rank. How important these characters really are seems to have been first appreciated by Van Beneden, who remarked in 1885: "Qui aurait pu se douter que la caisse tympanique et la surface articulaire de la mandibule des Mystacocètes auraient pu fournir les caractères les plus importants pour distinguer des genres et même les espèces?" [1]

[1] Ann. Mus. Roy. d'Hist. Nat. Belg (1885), **9**, p. 2. Emphasis is here laid upon the tympanic, because this is the more characteristic bone amongst the Balaenidae,

MYSTACOCETI.

Balaenidae.

A. Balaenine Section. — The tympanic is deep and more or less rhombic, its inflation comparatively slight, the involucrum (*i. e.*, the reflected superior portion of the inner wall of the bone) not fig-shaped, and frequently with no well marked depression at the anterior extremity of the superior border of the inner surface for the Eustachian canal.

B. Balaenopterine Section. — The tympanic is long, much inflated, rounded, with the involucrum much thickened and more distinctly pyriform, and the notch for the Eustachian canal always well marked. The tympanic varies in different individuals of the same species much less than in the Balaenine section.

ODONTOCETI.

Physeteridae.

The anterior facette of the periotic for articulation with the tympanic is quite smooth; the posterior tympanic surface of the former is broad, and carries a median longitudinal ridge. Tympano-periotic rigidly united with the cranium by a bony process.

Hyperoodon.

The posterior portion of the periotic is shortened, the median ridge on the tympanic aspect of the same very strongly developed, the accessory ossicle (*processus tubarius*) large and rounded, and the anterior tympanic facette slightly concave.

Kogia

Tympanic and periotic firmly united with each other by their anterior processes only, the posterior processes being widely separated and embracing between them a portion of the mastoid bone. Tympanic bulla scarcely inflated, aperture for Eustachian canal vertically constricted, sigmoidal process knob-like and prominent. The apertures seen on the inner aspect of the periotic (that which is turned away from the tym-

of which the author is speaking, and the one most commonly occurring in the fossil state. Amongst Odontocete whales and Delphinoids, on the other hand, the more important distinctive characters are furnished by the periotic. The analysis here given for the family divisions is taken chiefly from Dr. R. Lydekker's Catalogue of the Fossil Mammalia in the British Museum (1887).

panic) are round, relatively small, and distinct, characters which readily distinguish this element from Delphinoid periotics.

Delphinidae.

The anterior facette of the periotic for articulation with the tympanic is deeply grooved, the posterior tympanic surface of the former is comparatively narrow, and its ridge for articulation with the free border of the tympanic is ill-defined and situated close to one edge. The attachment of the two elements to the cranium is secured by ligaments only, not by bony union. Porus acusticus relatively large and of oval outline.

Delphinus.

Although the ear-bones of the type species, *D. delphis* Linné present easily recognized peculiarities, yet, owing to the restricted sense in which the generic term is now employed,[1] it does not appear possible to formulate a diagnosis from such minor details which will enable us to distinguish this genus from all other Dolphins by means of ear-bones alone. It is to be noted that some of the "Albatross" ear-bones agree very closely with the existing *D. delphis*, the resemblance being closer than with any known fossil species; yet we cannot be sure of absolute specific identity.

Comparisons with recent forms. — The remark just made with reference to Delphinus applies also to Kogia, a genus which has not been recognized with certainty in the fossil state, and is represented by at least three well-characterized living species. The few deep-sea ear-bones which have been obtained do not differ in any material degree from those of the supposed nearest ally of Physeter, *Kogia breviceps*. Three examples are shown in Plate **3**, Figs. 24–26, and one very perfect specimen has been figured in an earlier Report. These may all be assumed to belong either to the pygmy sperm whale or to a closely allied species.

The case of Hyperoodon is somewhat different, inasmuch as the deep-sea ear-bones referred to this genus cannot be identified either with the existing *H. rostratus* or with any known fossil form. Although it is clear that a distinct species is represented, no necessity appears for designating it by a new name, for the simple reason that no satisfactory diagnosis can be framed upon the evidence of ear-bones alone. The principal differences to be noted between the "Albatross" material

[1] True, F. W., Review of the Family Delphinidae. Bull. 36, U. S. Nat. Mus., (1889), 191 pp., pl. 46. — On Species of South American Delphinidae described by Dr. R. A Philippi in 1893 and 1896. Proc. Biol. Soc. Wash. (1903), **16**, p. 133–144.

and the existing *H. rostratus* are as follows: The posterior articular facette of the periotic is more deeply concave in the deep-sea specimens, the "accessory ossicle" (*proc. tubarius*) is relatively smaller and scarcely inflated, the channel for the Fallopian canal on the tympanic aspect is less distinctly marked, and the promontory, or capsule containing the semicircular canals, is less expanded. Some minor differences are also to be observed in the relative size, arrangement, and direction of the apertures seen on the cerebral side of the periotic. The involucrum of the tympanic is not serrated, although the corresponding part in the living species displays as many as six or seven prominent denticles. Two specimens each of the periotic and tympanic, dredged from three different stations, are represented in Plate 2, Figs. 33–36.

Peculiar markings of certain deep-sea ear-bones. It deserves mention, in conclusion, that none of the ear-bones dredged by either of the "Albatross" Expeditions show any indications of surface markings comparable to those observed in two specimens, belonging respectively to the right and left sides, of Balaenine tympanic bullae brought up from one of the "Challenger" stations (No. 286) in the South Pacific. As the bullae are of corresponding form and proportions, and are stated to exhibit similar markings, it is extremely probable that they belonged to a single individual, and that their incised lines are a natural feature, rather than the result of post-mortem injuries. A certain amount of regularity is to be observed in the disposition of the grooves. They are not distributed at haphazard, nor do they intersect one another at varying angles, as we should expect them to were they of accidental origin. Furthermore, the bone substance is so exceedingly hard and dense that a knife-blade makes no impression upon it; only with the file is an incision possible. Yet it has been suggested that the indentations noticed in the "Challenger" ear-bones were caused by sharks' teeth. This conjecture was first advanced by J. Thoulet,[1] and an attempt to lend some color of probability to it was made later by A. Portis.[2]

The authors of the volume on Deep Sea Deposits of the "Challenger"

[1] Thoulet, J., Les depots sous-marins. Rev. Scient., (1892), **50**, p. 105.

[2] Portis, A., Un Dioplodonte nel pliocene astigiano. Rev. Ital. di Paleont., (1897), **3**, p. 34–39. Consult also the earlier memoir of the same author entitled "Nuovi studi' sulle traccie attribuite all' uomo pliocenico." Mem. R. Acc. Sci. Torino, ser. 2 (1884), **35**, p. 327–354. In Plate 1 Fig. 1 of this memoir is shown a tooth of *Carcharodon angustidens* actually embedded in a vertebra of Halitherium,

Reports do not undertake to account for the incised condition of the pair of ear-bones from Station 286, and show the grooved aspect of only one of them in Plate 7, Fig. 5, of their Report. In the explanatory legends, however, it is stated that "the markings shown in Fig. 5 were found on both of the bones, and are of the same character; these are the only bones taken during the cruise with such marks, and they differ from all the other ear-bones in other respects as well as in the markings." Professor Thoulet's interpretation is expressed in such positive terms, and is accepted with such readiness by Dr. Portis, that his views may best be set forth in his own words, as follows:

Une figure de MM. Murray et Renard représente un os de baleine sur lequel sont indiquées des marques arrondies, se coupant mutuellement et ressemblant a s'y méprendre aux incisions couvrant une omoplate de Balaenotus tertiare trouvée à Monte-Aperto, en Italie, par M. Capellini. M. de Quatrefages s'était justement basé sur ces dernières pour admettre l'existence de l'homme tertiare, car il se déclarait dans l'impossibilité de les attribuer à une autre cause qu' à l'action d'un instrument tranchant. L' échantillon du *Challenger*, autant qu 'il est permis d'en juger sur des dessins, paraît résoudre la question de la manière la plus nette et contrairement aux conclusions de M. de Quatrefages; les incisions ne peuvent être que la trace des dents de Squales.

The above explanation would undoubtedly answer for any other portion of the skeleton except dental tissue and bones of the auditory region. Its inapplicability to the latter may be demonstrated by a simple experiment. One may take any kind of shark's tooth whatsoever, recent or fossil, and try to obtain similar channelings and indentations on Cetacean ear-bones by forcible rubbing of the parts together. It will be found that the surface of the ear-bone is barely scratched by the apex of the enameled crown; and that, as between the two bodies, the shark's tooth is the more easily worn away.

thus confirming a conjecture made fifteen years earlier by Delfortrie. The latter's publications are to be found in the Actes de la Société Linnéenne de Bordeaux, (1869–72), **27**, **28**.

EXPLANATION OF PLATES.

PLATE 1.

Chart showing position of the stations occupied by the "Albatross" during her cruise in the Eastern Pacific in 1904–1905.

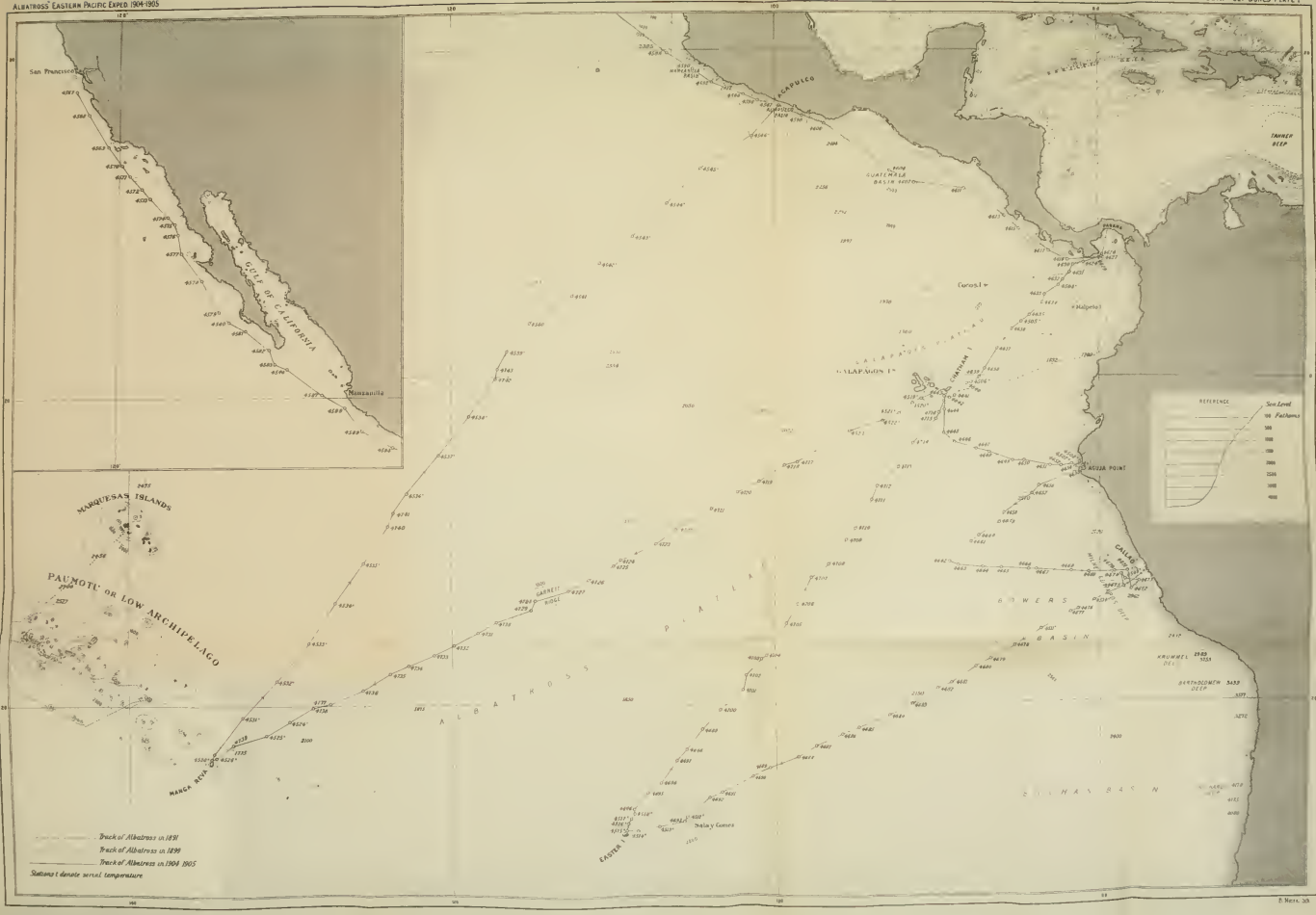
San Francisco
Manzanilla
GULF OF CALIFORNIA
MARQUESAS ISLANDS
PAUMOTU OR LOW ARCHIPELAGO
MANGAREVA
EASTER
Salas y Gomez
GALAPAGOS I.
CHATHAM
CHARLES
Cocos I.
Malpelo I.
PUNTA AGUJA POINT
CALLAO
TANNER BEEP
GUATEMALA BASIN
BOWERS BASIN
KRUMMEL DEEP
BERTHOLOMEW DEEP
ALBATROSS
REFERENCE
Sea Level
100 Fathoms
Track of Albatross in 1891
Track of Albatross in 1899
Track of Albatross in 1904-1905
Stations denote serial temperature

PLATE 1A.

Chart showing tracts of the "Albatross" and "Challenger" Expeditions in the Pacific. Stations yielding vertebrate remains indicated by round dots; the so-called barren region by oblique lines.

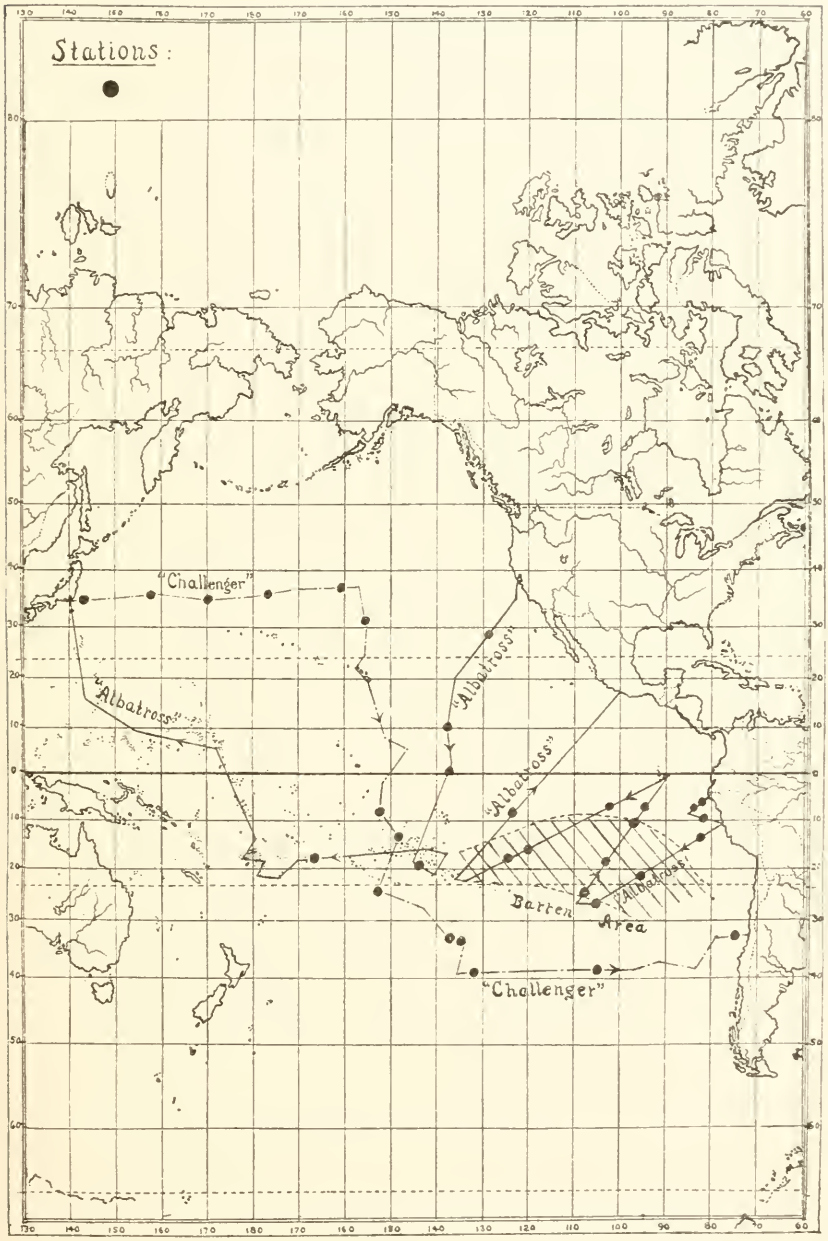
Stations:
"Challenger"
"Albatross"
"Albatross"
"Albatross"
"Albatross"
Barren Area
"Challenger"

PLATE 2.

(*All figures are of the natural size.*)

FIGS. 1–3. *Oxyrhina crassa* Ag., Station 4658. Small postero-lateral teeth seen from the inner or convex face.

FIGS. 4, 5. *Oxyrhina crassa* Ag., Station 4656. Small postero-lateral teeth.

FIGS. 6, 7. *Lamna* sp. ind., Station 4656. Two anterior teeth of a small species seen from the inner or posterior aspect.

FIGS. 8, 9. *Oxyrhina crassa* Ag., Station 4701. Small postero-lateral teeth.

FIGS. 10–12. *Oxyrhina crassa* Ag., Station 4685. One anterior and two lateral teeth, all seen from the inner, convex face.

FIG. 13. *Carcharodon lanciformis* Gibbes, Station 4685. Small posterior tooth having manganese concretions attached to it.

FIGS. 14–16. *Oxyrhina crassa* Ag., Station 4685. Anterior teeth, seen from different faces, and having small nodular masses of manganese attached to them.

FIG. 17. *Oxyrhina crassa* Ag., Station 4685. Small posterior tooth having the interior filled with concretionary manganese.

FIG. 18. *Oxyrhina* sp. ind., Station 4701. Finely preserved tooth of less robust form than the preceding, not unlike *O. hastalis* in some respects, and with scarcely any incrustation.

FIGS. 19–22. *Carcharodon lanciformis* Gibbes, from following stations in consecutive order: 4685, 4732, 4656, and 4685. All seen from the inner face, which is but slightly convex. The original of Fig. 20 has several worm tubes attached to it.

FIG. 23. *Carcharodon megalodon* Ag., Station 4740. Very large and well preserved lateral tooth, seen from flattened external face. The interior is filled with a deposit of manganese.

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PLATE 3.

(*All figures are of the natural size.*)

FIGS. 24, 25. *Kogia* sp., very similar to *K. breviceps*. Left and right periotics, respectively, the former from Station 4740, the latter from Station 4721.

FIG. 26. Imperfect right tympanic belonging to same species as the preceding, from Station 4721.

FIGS. 27, 28. *Delphinus* sp., somewhat resembling *D. delphis*. Left and right periotics respectively, from Stations 4701 and 4740. The right periotic is seen from the tympanic aspect, and has the stapes still seated in the fenestra ovalis. The longitudinal extent of the porus acusticus, as compared with that in Fig. 25, is noteworthy.

FIG. 29. Same as Fig. 26, but more perfect, and heavily encrusted. Station 4721.

FIG. 30. Right periotic of unknown Delphinoid species, somewhat encrusted. Station 4685.

FIG. 31. Imperfect right tympanic of unknown Delphinoid species, considerably encrusted. Station 4721.

FIG. 32. *Delphinus* sp., somewhat resembling *D. delphis*. Inferior aspect of left tympanic, Station 4740.

FIGS. 33–34. *Hyperoodon* sp. ind., Station 4666. Tympanic and periotic belonging to the left side of a single individual.

FIGS. 35–36. *Hyperoodon* sp. ind., Stations 4656 and 4676. Right tympanic and left periotic, more or less encrusted, turned to show opposite aspects from Figs. 33 and 34.

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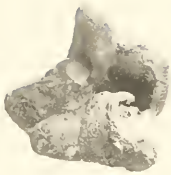

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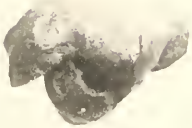

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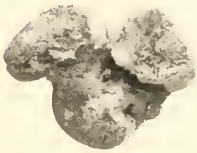

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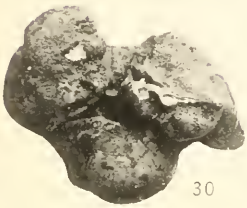

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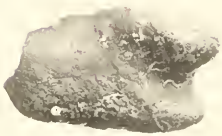

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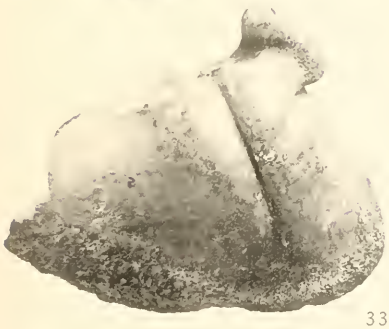

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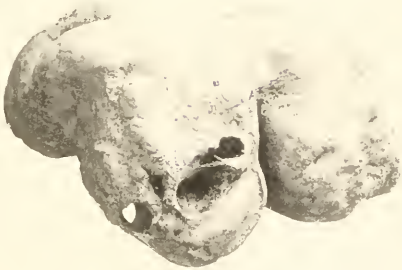

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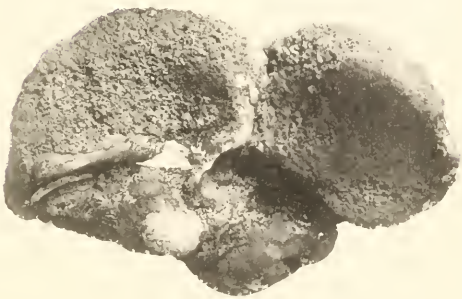

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HELIOTYPE CO., BOSTON.

Bulletin of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
VOL. L. NO. 5.

VERTEBRATA FROM YUCATAN.

INTRODUCTION. AVES.

By Leon J. Cole.

MAMMALIA.

By Glover M. Allen.

REPTILIA; AMPHIBIA; PISCES.

By Leon J. Cole and Thomas Barbour.

With Two Plates.

CAMBRIDGE, MASS., U. S. A.:
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November, 1906.

No. 5. — *Vertebrata from Yucatan.*

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1. INTRODUCTION. By Leon J. Cole.

The following papers upon the vertebrates of Yucatan are based upon collections and notes made by the writer during a visit to that country in the early part of 1904. In addition there have been included several smaller collections from other sources. The trip was made, through the generosity of Mr. Alexander Agassiz, in the interest of the Museum of Comparative Zoölogy. Its primary object was a study of the animal life of certain deep water-holes, or *cenotes*, in the vicinity of the ancient ruined city of Chichen-Itza. The present papers, however, deal almost entirely with collections made independently of that work, since the vetebrate fauna properly belonging to the cenotes is very small, comprising only three or four species of fish, two or three anurans that lay their eggs in the water, and a single species of turtle. Iguanas and other lizards, it is true, find convenient habitations in the rocky walls, while the presence of an abundant supply of water, together with the more luxuriant foliage, attracts to the vicinity numerous birds and other animals which are scattered throughout the forests.

By far the larger part of the collections were made at Chichen-Itza, but some collecting was also done at other places, notably at Progreso. All of the fishes, with the exception of three species, are from the latter locality. In reporting upon the birds, the list for Chichen-Itza has been kept separate, but in the case of the other groups all the specimens obtained have been listed together.

A brief notice of the itinerary may be of interest as showing the periods spent at the different places. The places mentioned are indicated upon the accompanying sketch map of northern Yucatan.

I arrived at Progreso on January 27, where I was kindly received by Mr. E. H. Thompson, the United States consul. Mr. Thompson now owns the large plantation upon which the ruins of Chichen-Itza are situated, and I enjoyed his hospitality while there. As Mr. Thompson was unable to leave Progreso until February 11, I collected during the interval in its vicinity. One day, February 9, was spent at San Ignacio, a small station about ten or twelve miles from the coast, and half way to Merida. On February 11 we went to Merida, and the following morning took the train to Oitas, some ninety or one hundred miles to the

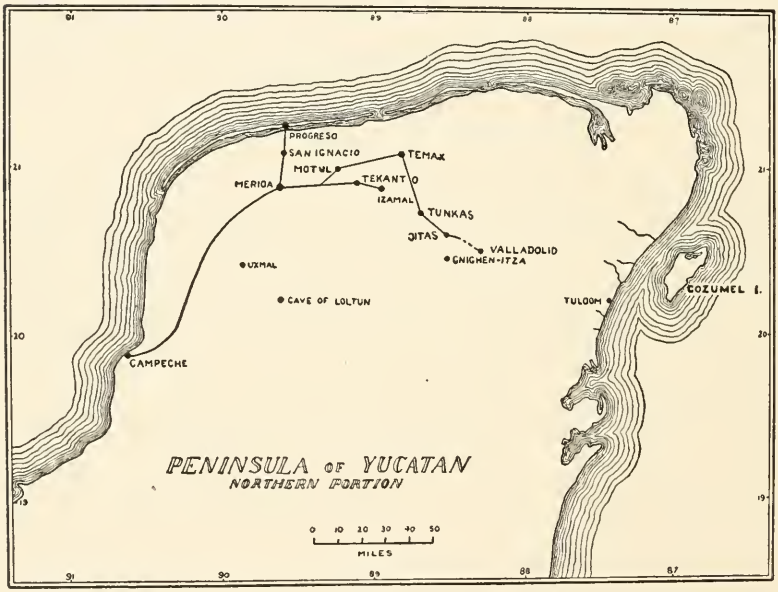


FIG. A.

eastward. The railroad is a narrow-gauge line, poorly equipped with modern appliances and conveniences; furthermore, it takes a roundabout course through the principal henequen (so-called "Sisal hemp") growing districts, so that the trip takes nearly a day. Some of Mr. Thompson's Indian servants met us at Oitas with horses, and on the morning of the 13th we rode to Chichen, fifteen or more miles to the southward. I remained at Chichen-Itza from February 13 to April 9. I then returned to Merida, and from there went to Izamal, where I was cordially entertained by Dr. George F. Gaumer, the veteran collector in Yucatan. I had no opportunity to collect at Merida or Izamal.

Further collections were made at Progreso and vicinity from April 12 to 17.

A word should be added as to the general character of the country.[1] The northern part of the peninsula is a soft limestone plain, which slopes gently up to the southward from the Gulf. The rock, in many places bare, is at best covered with only a scanty soil, not capable under the existing conditions of supporting a very luxuriant vegetation. There are no surface rivers, at least none of any permanence, the water sinking quickly into the porous limestone rock and finding its way to the sea by underground courses. There are, however, numerous caves and openings down to the water, which, in the northern part of the peninsula at least, appears to maintain a fairly constant level but little above that of the sea. These water-holes are known locally as *cenotes*.

The western part of the country, in the region of Merida, is largely cleared of the forests and given over to the growing of henequen, the plantations of which sometimes stretch away as far as the eye can reach. To the eastward the land is uniformly forested, except for occasional clearings for the growth of corn or sugar cane. Such is the country about Chichen-Itza, where from the top of one of the ancient ruins which rises above the forest one may look in all directions to the horizon over an almost level and unbroken sea of tree tops. Only here and there is the general level interrupted by a growth of taller trees about a cenote, or where the forest mounts over the crumbled pile of a prehistoric building.

Owing to the porosity of the rock and the scarcity of surface water, the conditions in northern Yucatan are much more arid than would at first thought be expected, and, as might be supposed, this has a noticeable effect upon the fauna. Many of the birds, for example, are distinguished as geographical races, and in nearly all cases this distinction is based upon their being smaller in size and paler in coloration than the representatives of the same species which live in the more humid regions of Mexico and the countries to the southward.

Progreso is situated upon a low-lying strip of sand between the Gulf on one side and an extensive mangrove marsh on the other. This marshy strip, spoken of as *la cienaga*, *el rio*, or *la laguna*, extends along

[1] A good description of the physiographic and climatic conditions of Yucatan may be found in a recent paper by David Casares, A notice of Yucatan, with some remarks on its water supply. Proc. Amer. Antiquarian Soc. for 1905, new ser., 1906, **17**, p. 207–230.

nearly the whole northern coast of Yucatan.[1] It is fed in large part by springs through which the underground water of the interior reaches the surface. Its breadth varies greatly with the season, being much greater during the period of rains. Its waters, which are brackish, abound with small fish, some of which are, however, large enough to be of food value; while birds, especially herons and water fowl, are abundant among the mangroves and on the open stretches. On the sandy costal strip the vegetation is low and scrubby, scarcely higher than one's head, and here small lizards constitute the characteristic faunal element.

At San Ignacio the "brush" is higher, but is not dense. Extensive areas are devoted to henequen growing, and it was in these open places that the Burrowing Owl was found. In many places the rock is bare and weathered, so that the numerous fossil shells imbedded in it stand out at the surface in bold relief. The country about Merida is practically the same.

At Chichen-Itza the forested condition prevails. In general the soil is somewhat thicker, but even here it only thinly covers the underlying rock, which crops out everywhere. The general topography is very flat and level, but is broken up somewhat by the unequal weathering of the rock and the erosion of temporary streams during times of heavy rains. Chapman[2] describes the forest as "a dense scrub of trees and saplings, averaging one and a half to three and a half inches in diameter and fifteen to thirty feet in height." There are, however, not infrequently trees of greater size. Here and there are clearings a few acres in extent where the Indians have established their *milpas* or corn fields. These are made by cutting down the larger trees and leaving them to dry. The place is then burned over at the end of the dry season, and the corn planted upon the approach of the rains. This process is very exhaustive to the soil, and the *milpas* consequently have to be changed frequently to new locations. A dense, scrubby growth, however, immediately springs up on the deserted area.

The cenotes deserve a word of special mention. There are two of these in the immediate neighborhood of the ruins of Chichen-Itza. The Sacred or Sacrificial Cenote is nearly circular in outline, with a diameter of one hundred and ninety feet, while its walls are vertical, and sixty-

[1] For a discussion of the nature and origin of the sandy costal strip and the *cienaga*, see Die Küstenbildung des nördlichen Yukatan, by Arthur Schott. Petermann's Geogr. Mittheilungen, 1886, **12**, p. 127–130.

[2] Chapman, Frank M. Notes on birds observed in Yucatan. Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 271–290.

five feet high from the level of the water to the general surface of the ground. The surrounding forest crowds to the very edge of the cenote, and a scanty vegetation clings to the irregularities of its walls. The water is fresh, is about thirty feet deep, and of a greenish color. The color appears to be due to algal plankton, and not to the depth as many authors have stated. The so-called Great Cenote in reality has a smaller diameter at the water surface than the other, but it appears larger by reason of its sloping walls. These afford lodgement for a vegetation which maintains a luxuriant growth in consequence of the never-failing supply of water.

The cenotes offer an interesting problem in connection with faunal distribution. Although it is maintained by many that they are all a part of a great underground river system, it seems fairly certain that many of them are not connected with the others by definite subterranean streams of any size, but that the general level is maintained rather by "seepage" through the loose, porous rock. Our knowledge of the fauna is as yet too limited to afford much evidence for either view, but such as there is appears to indicate a lack of underground connections of a size sufficient for fish to pass from one cenote to another. This matter is more fully discussed in the introductory remarks to the report on the fishes, and applies to the cenotes at Chichen-Itza; at other places, as at Izamal, there appears to be conclusive evidence of the connection of neighboring cenotes by passages of considerable size.

Although the period of my visit fell in what is the dry season in Yucatan, there was considerable rain, especially during the earlier part of the time. In the latter part of February and early March, heavy showers, frequently accompanied with thunder and lightning, were very common in the middle of the afternoon. During this period the air was usually clear, but on February 19, 20, and 21 there was a considerable fog in the early morning. Except when there were showers, there was nearly always a clear sky with bright sunshine; only a few days during the whole eight weeks were what could be called cloudy. In the latter part of March the weather became considerably warmer and much more typical of the dry season. Nearly every day there was a strong hot wind which seemed to dry up everything it struck. Previously one could always be comfortable when in the shade, so long as there was a breeze; now the hot wind added to one's discomforts. There was also a noticeable change in the animal life, especially the insects. Certain forms which I had not seen before, — such as a large species of fly which was very

troublesome to the horses and cattle, — became common, and the call of Cicadas became a characteristic sound in the forests, whereas not one had been heard before. This is the kind of weather the Indians depend upon for drying their *milpas*, and early in April they began burning them on all sides. The air soon became hazy with smoke, and from the summit of the *Castillo* great ascending columns could be seen in all directions as far as the eye could see.

Field work in Yucatan is made extremely uncomfortable by the abundance, especially in regions where cattle are allowed to run in the woods, of small ticks, locally known as *garrapatas*. These hang in clusters on the bushes and become brushed upon the clothes in countless thousands. Even with the greatest precaution great numbers of them find their way beneath the clothes, where they bury their heads in the skin and cause an irritation which at times becomes almost unbearable. Furthermore, nearly all the mammals and larger birds are covered with them, so that in making up the skins of these animals one receives a further supply of the ticks. The only remedy that was found to be at all efficacious was the free application of kerosene oil. It is said that during the summer months these pests almost, or even completely, disappear.

In conclusion, I cannot express too strongly my sense of indebtedness to both Mr. and Mrs. Thompson for their kindness and hospitality during my stay at Chichen-Itza, and in fact during the whole time that I was in Yucatan. A large room was placed entirely at my disposal, and everything was done that could be to aid my work. Only one who has gone into a strange country where an unfamiliar tongue is spoken can appreciate the advantage of having the constant aid and advice of those familiar with the country and its inhabitants.

2. MAMMALIA. By Glover M. Allen.

Specimens representing twenty species of mammals were obtained by Mr. Cole during his stay in Yucatan. Although none of these appears to be undescribed, several are of considerable interest on account of their rarity in collections. The list follows: —

DIDELPHIDAE.

1. Didelphis yucatanensis Allen.

The single specimen, a male, obtained March 31, 1905, is from the type locality, Chichen-Itza. The measurements taken by Mr. Cole from the fresh specimen are: length, 690 mm.; tail, 315 mm.; hind foot, 56 mm.

DASYPODIDAE.

2. Tatu novemcinctum (Linné).

A single male was secured at Progreso.

TAYASSUIDAE.

3. Tayassu angulatum yucatanense Merriam.

The skin and skull of a male from Chichen-Itza are in the collection, taken March 16, 1905. The measurements from the fresh specimen are: length, 795 mm.; tail, 190 mm.

CERVIDAE.

4. Odocoileus toltecus (Saussure).

Three skulls from Chichen-Itza seem to be referable to this species.

5. Hippocamelus pandora Merriam.

Two skins, one of them accompanied by a skull, were taken at Chichen-Itza. The total length of the female specimen is noted as 1020 mm. The male example measured: length, 970 mm.; tail, 85 mm.; hind foot, 265 mm.

SCIURIDAE.

6. Sciurus yucatanicus (Allen).

A single female was taken, and Mr. Cole notes that but few others were seen, in contrast to Mr. F. M. Chapman's experience in 1896, who found them "common at Chichen-Itza."

MURIDAE.

7. Mus rattus Linné.

A single specimen from Chichen-Itza was preserved.

8. Mus alexandrinus I. Geoffrey.

Two skins with skulls, from Chichen-Itza, are in the collection.

9. Mus musculus Linné.

The house mouse was abundant at Chichen-Itza. Several specimens trapped in the fields were preserved.

GEOMYIDAE.

10. Heterogeomys torridus Merriam.

A skin and skull in the collection, from Xbac, southeast of Izamal, seem referable to this species, though more specimens might show that the peninsular animal is distinct from those of Mexico proper. The specimen was obtained in 1901 by Dr. George F. Gaumer's collector.

HETEROMYIDAE.

11. Heteromys gaumeri Allen and Chapman.

A head of this species, with skull, taken at Chichen-Itza, was preserved.

AGOUTIDAE.

12. Agouti paca virgata Bangs.

A paca's skull was dredged from the Cenote at Chichen-Itza.

LEPORIDAE.

13. Lepus truii Allen.

A female specimen, taken at Chichen-Itza, seems referable to this species.

14. Lepus floridanus yucatanicus Miller.

A male was captured at Chichen-Itza.

CANIDAE.

15. Urocyon cinereoargenteus parvidens Miller.

The type of this subspecies was obtained at Merida, and the specimen secured by Mr. Cole at Chichen-Itza seems referable to it. Undoubtedly this is a small race peculiar to the arid portion of the Yucatan peninsula. The following measurements were taken from the fresh specimen: length, 740 mm.; tail, 281 mm. It was a female, and contained five embryos, March 6, 1904. Another fox, probably of this subspecies, was seen Feb. 9, 1904, at San Ignacio.

VESPERTILIONIDAE.

16. Rhogeëssa tumida H. Allen.

A single female was obtained at Chichen-Itza. I have found no other published records for this species from Yucatan, though its occurrence was to be expected.

MOLOSSIDAE.

17. Molossus nigricans Miller.

Seven specimens, all females, were taken at Chichen-Itza, where they were found in the roofs of dwellings. Miller, in his original description of the species, also records specimens from this locality.

18. Nyctinomops yucatanicus Miller.

A single female was obtained at Chichen-Itza, the type locality of the species.

PHYLLOSTOMATIDAE.

19. Otopterus pygmaeus (Rehn).

An adult male, captured March 5, 1904, at Chichen-Itza, appears to be the second recorded specimen of this very distinct dwarfed species. The type was

from Izamal, Yucatan, and probably represents a species characteristic of this arid portion of the peninsula. The following measurements in millimeters were taken from this specimen, and for comparison, those of the type are added in parentheses, as given in the original description (Rehn, Proc. Acad. Nat. Sci., Phila., 1904, p. 445): ear, 17 (17.2); greatest width of ear, 12.5 (13); tragus, 5 (7); forearm, 35.3 (35.5); thumb, 9.6 (10); third digit, 62.4 (65.5); tibia, 14.1 (14.9); calcaneum, 9.1 (9); foot, 8 (10.5); nose-leaf and pad, 8.3 (7.2); greatest zygomatic width of skull, 9.1 (9.2); extreme length of skull, 19 (—).

20. Artibeus yucatanicus Allen.

A male, taken at Chichen-Itza, the type locality, March 14, 1904, represents this recently recognized species.

3. AVES. By Leon J. Cole.

Mr. Frank M. Chapman, in his Notes on Birds observed in Yucatan,[1] published an excellent list of the birds observed by him at Chichen-Itza, Yucatan, during the month of March (3-21) of the same year. Although much collecting had been done in a general way in the peninsula for many years, so that the bird fauna was comparatively well known, this was the first strictly local list for any part of the country. Until recent years, when the railroads have been much extended, Chichen-Itza was rather inaccessible and difficult to reach; and as a consequence, with a few exceptions, most of the naturalists and collectors who have visited Yucatan have confined their operations to within a comparatively short radius of Merida. As early as 1841 and 1842 Dr. Samuel Cabot, Jr., in company with the explorer Stephens, journeyed over much of the northern part of Yucatan, including in his travels a visit to Chichen-Itza, and even to the island of Cozumel off the eastern coast. Stephens published a brief "Memorandum" of Cabot's results in the second volume of his Incidents of Travel in Yucatan (Harper Brothers, 1843), but with a few exceptions definite localities are not given. The most extensive collecting in the peninsula was done from twenty to thirty years ago by Dr. Geo. F. Gaumer, who is still living at Izamal. Many of his notes were published by Boucard in the Proceedings of the Zoological Society of London, 1883; and in many cases exact localities are mentioned, so that the records have value from a distributional standpoint. His collections, however, went to various persons, though many of them finally came into the hands of Salvin and

[1] Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 271-290. This article includes a good bibliography of the principal papers relating to birds published before 1896.

Godman, and formed the principal material for the notes on Yucatan birds in the Biologia Centralia-Americana. So far as I am aware, there is no specific record of birds collected at Chichen-Itza by Gaumer.

Since Chapman's visit, and previous to my own, Messrs. E. W. Nelson and E. A. Goldman, of the United States Biological Survey, spent a short time at Chichen-Itza, and Nelson has published a number of notes and descriptions of new or rare forms procured by them.

In spite of the remarkable uniformity of the greater portion of the northern part of the peninsula of Yucatan, there is a marked difference in the bird fauna of the costal belt and the interior; and apparently also between those parts of the country where the forests have been very largely cleared away to give room to henequen plantations, and the wilder portions to the eastward, which are still densely wooded. For this reason, as Chapman says, as well as for the information to be obtained regarding migrations and the more casual wanderings of the birds, local lists seem desirable. The present paper is an attempt to make more complete the list of winter birds of Chichen-Itza.

As has been mentioned, my stay at Chichen-Itza covered a period of eight weeks — from February 13 to April 9, 1904. Only a small portion of this time, however, was given to the observation and collection of birds, which was rather incidental to the other collecting. I have already expressed my deep gratitude to Mr. E. H. Thompson for his hospitality, and it gives me pleasure to add that I owe fully as much to him for his interest in my work with the birds. Not only did he give me every information at his command, but by furnishing them with powder and shot, he arranged it so that the Indians on his plantation brought me many birds which I should otherwise probably have been unable to procure. I am also indebted to Mr. Thompson for assistance in obtaining the Maya names of the birds and for the translation and explanation of the meanings of some of these.

Chapman in his paper has given a good description of the character of the country, and something has been added in my general introduction, so that little more need be said here. It is doubtful, however, if the portion to the eastward of the henequen belt has ever been so completely deforested as Chapman believes. It is probable rather that the general low, "scrubby" character of the vegetation is due to the arid conditions of the peninsula — to the thinness of the soil and the porosity of the underlying rock. There are, however, as Chapman says, trees of certain species which attain a considerable size, and especially is this true in the immediate vicinity of the cenotes.

Chapman has also given a discussion of the origin of the Yucatan avifauna, and later researches only tend to confirm his conclusion that it is essentially Central American in its character. Recent explorations have not done much in the way of adding new species, but a number of forms have been split off as varietal. As is to be expected in an arid country, these are in nearly all cases distinguished from their relatives of Mexico, Guatemala, Honduras, and neighboring regions to the southward by their smaller size and paler color.

The weather during the period I spent at Chichen was more rainy than is usual for the dry season, and this may have had some influence on the bird life. But the general aspect was one of winter, or early spring, in spite of the warmth and the occasional flowers. This was emphasized by the fact that many of the birds were to be found in droves or flocks made up of a number of species, much as they are in our own woods in the autumn and winter months. Thus one would often meet with droves of warblers of various species, or of wood hewers, ant thrushes, and the like. The jays, cowbirds, ground doves, parrots, and even flycatchers, were usually in flocks of their own kind, while the hawks, wrens, tanagers, cardinals, and other finches were usually to be found singly or in pairs. Baker apparently found this peculiarity even more marked in the vicinity of Tekanto, for he writes (A Naturalist in Mexico, 1895, p. 32): "While hunting along the narrow path-ways through the forest in the neighborhood of the camp, we would pass several hours without seeing many birds; but now and then the surrounding bushes and trees appeared suddenly to swarm with them. There were scores of birds, all moving about with the greatest activity — Crotophaga, woodpeckers, tanagers, flycatchers, and thrushes, flitting about the lower leaves and branches. The bustling crowd lost no time, but hurried along, each bird occupied on its account in scanning bark, leaf, or twig in search of insects. In a few minutes the host was gone, and the forest remained as silent as before."

The attempt has been made in the present list to include every species of bird known to have been definitely reported from Chichen-Itza, bringing the total number to one hundred and twenty-eight species and subspecies. This is an increase of fifty-four over Chapman's list, which enumerated seventy-four forms. The additions are from four sources: (1) Birds collected or observed by myself; (2) Easily recognizable birds added on the authority of Mr. Thompson; (3) A collection of skins made by Mr. Thompson in the early nineties; (4) Records from other sources. My own collections were made with the idea of obtaining as

representative a series of the birds as possible, so that in most cases only one or two of a species were taken. These are now in the Museum of Comparative Zoölogy. Two birds which seemed unmistakable are included on Mr. Thompson's authority as being at times found at Chichen. These are the Barn Owl (*Strix pratincola*) and the Mexican Road Runner (*Geococcyx affinis*). Others, concerning which there was less certainty, have not been included. The collection of skins mentioned as having been made by Mr. Thompson (with the aid of a native, under his direction) in the early nineties, comprised eighty-four specimens, representing fifty-three species, among which were nine not otherwise known for the locality. Many of these are also, through his generosity, now in the Museum of Comparative Zoölogy. And, finally, there is a single addition depending upon a record found elsewhere — that for the Central American Boatbill collected by Cabot, and mentioned by Stephens.

Chapman lists ten forms for which I have no other records; these are included here for the sake of completeness, but have been enclosed in brackets so that they may be distinguished. All species recorded by Chapman are preceded by an asterisk in order to facilitate comparison of the two lists.

It must be borne in mind that this is essentially a list of the *winter* birds at Chichen-Itza. As has been stated by Chapman, Gaumer, and Baker, there is probably a considerable migration to the southward from northern Yucatan at this time of year, but concerning such migration there is comparatively little definite information at hand. The birds from Mr. Thompson unfortunately, in most cases, bear no data as to the time of year they were collected; but it is not improbable that some of them are to be found at Chichen-Itza only during the summer months, which include the rainy season. In the case of *Columba speciosa* I obtained direct information that it was common in the summer, but was not there in the winter, and it is possible that the same is true of *Claravis pretiosa*, *Pteroglossus torquatus*, and other birds which were not obtained by either Chapman or myself during our visits in the winter months. In fact, I am under the impression that certain species, such as *Merula grayi* and *Megaquisculus major macrourus*, which I saw only during the latter part of my stay, may have been the returning vanguard of these southern migrants.

No systematic effort at collecting or observing birds was made except at Chichen; but in many cases such incidental notes as were made at other places have been added, the locality being given in each case. A

series of fifteen skins, kindly given me by Dr. Gaumer when I had the pleasure of visiting him at Izamal, is included. Most of these, Dr. Gaumer states, were taken at Xbac, his plantation, some distance to the southeast of Izamal; but as no localities were given on the labels, it has seemed best to record them in nearly all cases as from "Yucatan," the more so as several of the records would be very unexpected so far from the coast. In this connection it is worth while, however, to call attention to the relatively large list of water birds now known from Chichen. These birds are apparently casual wanderers there, attracted by the water of the cenotes, and undoubtedly with continued observation over a longer period the list would be greatly extended.

A short additional list has been added, giving a few incidental notes on birds not as yet recorded from Chichen-Itza.

An attempt was made to obtain, so far as possible, the native Maya names of the birds, and these are given for each species for which they could be learned.[1] In the case of the larger forms there was little difficulty, but as might be expected, the smaller and less conspicuous birds were not so well known, and very often the natives appeared not to have different names for distinguishing them, but applied a common name to the whole lot.[2]

[1] For the system of phonetics used in representing the Maya sounds I am indebted to Dr. Alfred M. Tozzer, Instructor in Anthropology in Harvard University, who has spent portions of the past four winters among the Maya Indians in a study of their language and customs. The following "key" will aid in giving an idea of the pronunciation of the words. The equivalent letters given by Beltran de Santa Rosa in his Maya grammar are indicated for the purpose of comparison, since his symbols have usually been employed in part by those who have published Maya names of birds, and are used in the names of many of the Yucatan cities.

Key to the pronunciation of Maya words.

The vowels and consonants have their *continental* sounds, with the following exceptions:

ă like *u* in h*u*t,	š (Beltran *x*) like *sh* in hu*sh*.
ai like *i* in *i*sland,	tš (Beltran *ch*) like *ch* in *ch*urch,
k (Beltran *c*) ordinary palatal *k*,	tš̌ (Beltran *čh*) *tš* explosive,
q (Beltran *k*) velar *k* (explosive),	p̣ (Beltran *pp*) *p* explosive,
ǫ (Beltran ɔ) *ts*, explosive or fortis,	t̤ (Beltran *th*) *t* explosive.
ɔ (Beltran *tz*) *ts* non explosive,	Doubled vowels should be doubled in pronunciation.

[2] Some of the Maya dictionaries and vocabularies give the names of a few of the birds, but it is usually difficult, and often impossible, to determine the species meant. Gaumer gave a number of the Maya names in the notes published by Boucard (Proc. Zool. Soc., Lond., 1883), and a few are given also by Norman in his

The "stomach contents" of a considerable number of birds were preserved with the idea of gaining some knowledge of their food. Mr. F. S. Millspaugh, of the Field Columbian Museum, who is probably more familiar with the Yucatan flora than any other botanist, kindly undertook for me the identification, in so far as possible, of the seeds and other parts of plants included in these collections, and his determinations have been inserted in each case under the notes on the species in question. Although they are of interest now only in a general way, it is hoped these observations may be of use when a study of the economic value of these birds is made.

In the identification of the specimens obtained I am very deeply indebted to Mr. O. Bangs, who has also given me much assistance in other ways. Furthermore, I wish to express my thanks to Messrs. E. W. Nelson, Robert Ridgway, and Witner Stone for the examination and comparison of certain of the birds.

LIST OF THE BIRDS OF CHICHEN-ITZA, YUCATAN.

TINAMIDAE.

1. Crypturus sallaei goldmani Nelson.

Proc. Biol. Soc. Wash., 1901, **14**, p. 169.

Yucatan Tinamou.

Maya name, *nom;* Spanish, *perdiz.*

A single specimen was brought me by the Indians (March 12, 1904). It was so badly mutilated that its sex could not be determined. The species appears to be common over the whole of the northern part of the peninsula (Biol. Centr.-Amer., **3**, p. 456). The type specimen is from Chichen-Itza.

Legs, when fresh, orange.

With regard to the food, as determined from this specimen, Mr. Millspaugh reports:

"This bird is a very heterogeneous seed-eater, with an evident tendency towards selecting those of a euphorbiaceous character. It is particularly noticeable that so few seeds occur of many species that seed largely, the bird strangely selecting but a few of each. The craw contained the following euphorbiaceous seeds: 1 *Tragia nepetaefolia;* 1 *Croton cortezianus:* 1 *Dalechampia* species; 4 *Croton lobatus;* 2 capsules *Euphorbia astroites* (with ripe

Rambles in Yucatan (New York, 1843). It is very common for the Indians in giving the names of the birds to attach to them the feminine prefix š (Beltran *x*). Thus *pū-hui* (p. 127) becomes *špū-hui; ṭuuṭ* (p. 125) becomes *šṭuuṭ; kū-sam'* (p. 134) becomes *škū-sam'; ta-pīn* (p. 142) becomes *šta-pīn*, etc.

seeds); 1 capsule *Tragia nepetaefolia* (with ripe seeds); 7 seeds *Croton* species; 54 seeds *Croton* species; 3 unknown species of seeds (one seed each).

"1 bit of leaf of *Peperomia* species; 1 whole wasp.

"The following verbenaceous species: 1 seed *Tamonea scabra;* 4 seeds *Stachytarpheta jamaicensis;* 1 nutlet, unknown species.

"1 fruiting calyx of some unknown mint; 4 capsules containing 2 seeds of *Henrya costata;* 24 seeds of some unknown acanthaceous species; 3 seeds of *Cedrela ororata;* 1 ripe fruit *Morinda roioc;* 6 seeds some unknown euphorbiaceous plant; 5 seeds some unknown legume; 4 seeds *Heliotropium indicum.*"

CRACIDAE.

2. *Ortalis vetula pallidiventris[1] Ridgway.

Yucatan Chachalacca.

Maya name, *baatš.*

One specimen: ♀, March 15, 1904.

Chapman mentions hearing these birds calling only in the morning. I heard them more often just at dusk, and only once, when the sky was overcast just before a shower, did I hear one in the middle of the day.

A native in Progreso, the proprietor of a chocolate shop, had two of these birds alive about his place. They were as tame as domestic fowls, and ate bread, cakes, and similar food. I succeeded in purchasing these two birds, intending to take them to the New York Zoölogical Park, but unfortunately only one of them lived to reach there.

MELEAGRIDAE.

3. *Agriocharis ocellata (Cuvier).

Ocellated Turkey.

Maya name, *kuɔ.*

One specimen: ♂, March 30, 1904.

Not infrequently brought in by the Indians, who cook it as they do most of their meat. They place it in a hole in the ground where they have had a fire, and cover it over with banana leaves, then with palm leaves and earth. Even when thus cooked the flesh is delicious.

ODONTOPHORIDAE.

4. *Eupsychortyx nigrogularis (Gould).

Colinus nigrogularis (Gould). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 289.

Yucatan Bob-white.

Maya name, *betš.*

Two specimens:

a. ♂, March 4, 1904.

b. ♀, Progreso, Feb. 8, 1904.

[1] All species recorded from Chichen-Itza in Chapman's list are preceded by an asterisk.

This bird occurred in flocks in the clearings of Chichen-Itza, where its call, resembling very closely that of *Colinus virginianus*, was often heard. A single moderate-sized flock was seen among the low growth on the sandy soil near Progreso.

5. Dactylortyx thoracicus sharpei Nelson.

Proc Biol. Soc. Wash., 1903, **16**, p. 152.

Yucatan Long-toed Grouse.

Maya name, *betš*.

One specimen: ♀, March 7, 1904.

This subspecies was described from a specimen taken at Apazote, Campeche, by Nelson and Goldman. Mr. Nelson has kindly examined the present specimen for me, and pronounces it typical. Previously specimens had been taken by Dr. Gaumer at Tizimin and at Peto, and he reports it as "equally common in all the eastern forests of Yucatan" (Biol. Centr.-Amer., **3**, p. 309, under *D. thoracicus*).

Mr. Millspaugh reports as follows upon the contents of the craw of this specimen: "This bird evidently feeds almost entirely upon the seeds of euphorbiaceous and leguminous plants. I find: 5 beans from some unknown *Phaseolus;* 40 beans of *Phaseolus semierectus;* 15 seeds of *Dalechampia* species; 4 seeds of *Jatropha* species; 2 seeds of an unknown *Euphorbia;* 1 seed unrecognizable; also about two drachms of the seed coats macerated beyond recognition."

COLUMBIDAE.

6. Columba speciosa Gmelin.

Dr. Gaumer presented me with a skin of this bird, said to have been taken at Xbac in 1901. At Chichen-Itza I saw a live specimen in a cage in an Indian hut, and was told that the bird was taken in that vicinity the previous summer. The Indians say they are not there during the winter months.

7. *Columba flavirostris Wagler.

Red-billed Pigeon.

Maya name, *ku-kut-kīp'*.

Three specimens:

a. ♀, March 5, 1904.

b. Chichen-Itza, 189–, E. H. Thompson (Pablo Perera).

c. Chichen-Itza, 189–, E. H. Thompson.

Bill, feet, and legs red.

Mr. Millspaugh reports: "This craw contains four fruits of some sapotaceous species, possibly a *Chrysophyllum;* one of these fully ripe, the other three immature."

PERISTERIDAE.

8. *Melopelia leucoptera (Linné).

White-winged Dove.

Maya name, *sak-pa-kal'*.

Five specimens:

a. ♂, March 10, 1904.
b. ♀, March 12, 1904.
c. (alcoholic), 1904.
d, e. Chichen-Itza, 189–, E. H. Thompson.

Common. Skin around eye, blue; iris, brick red; feet, bright red.

9. *Columbigallina passerina pallescens (Baird).

Mexican Ground Dove.

Two specimens:

a. Chichen-Itza, 189–, E. H. Thompson.
b. ♂, San Ignacio, February 9, 1904.

Chapman reports this bird as common at Chichen-Itza. I supposed that I had seen both species of Ground Dove there, but find only *C. rufipennis* among my skins. I obtained one specimen (a male) of the present species at San Ignacio, on February 9, and have a specimen from Chichen-Itza in the Thompson collection.

10. *Columbigallina rufipennis (Bonaparte).

Rufous Ground Dove.

Maya name, *mu-kui*.

Five specimens:

a. ♀, Feb. 26, 1904.
b. ♀, March 28, 1904.
c. ♂, April 3, 1904.
d. ♂, April 3, 1904.
e. fledgling, March 28, 1904 (alcoholic).

Very abundant and tame about the yard, garden, and corrals at Chichen.

Two nests of this species were collected on March 28. They were situated in lime trees in the garden, and not over thirty meters from the house. One of the nests was first discovered on March 26, at which time it contained a single egg; on the 28th there were two eggs, both of which were fresh. They are equally rounded at either end, and measure respectively 21.8 mm. × 16 mm., and 22 mm. × 16.5 mm.

The other nest contained a single fledgling. The female, when disturbed, flew to the ground and fluttered away as if wounded. The nest was placed next to the main shaft of the tree on a small branch, at about three meters from the ground. Both nests are about 9 cm. in diameter and 5 or 6 cm. deep. In one (that containing the eggs) the depression is very slight; in the other the cup is rather deep (about 2 cm.), suggesting the possibility that the nest is added to after the eggs are laid. It seems more probable from its appearance, however, that this is an individual variation in construction. Both nests have a foundation of lime or other leaves, the upper part being rather compactly built of small stems, with a little grass and a few rootlets.

The lower part of the crop of the mother of the young bird was hypertrophied, and exuded the secretion known as "pigeon's milk."

Iris of males, yellow.

Mr. Millspaugh reports that the craw of the mother bird contained "200 seeds representing four unknown species of the euphorbiaceous genus *Croton.*" With regard to the two males taken on April 3d, he says; "One of the craws contained two large and fully ripe fruits of some cultivated species of Day lily (*Crinum*). These fruits must have been about 1½ inches in diameter, and were completely filled with a multitude of ripe, bony seeds. There were also found under this number: 46 seeds *Tragia nepetaefolia;* 8 seeds *Croton* species; 2 minute seeds of some scrophulariaceous plant; 43 seeds *Croton flavens;* 14 seeds *Croton albidus;* 1 seed *Croton* species; 2 seeds representing two unknown species."

11. Claravis pretiosa (Ferrari-Perez).

Two specimens:

a. ♂, Chichen-Itza, 189–, E. H. Thompson (Pablo-Perera).

b. Chichen-Itza, 189–, E. H. Thompson.

12. * Leptotila fulviventris fulviventris Lawrence.

Leptotila fulviventris brachyptera (Salvad.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 287.

Leptotila fulviventris (not *brachyptera*) Laur. Salvin and Godman, Biol. Centr.-Amer., **3**, p. 259.

White-fronted Dove.

Maya name, *ɔu-ɔui.*

Two specimens:

a. ♀ (?), March 5, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

Contents of craw: "six bony nutlets of some unknown species, and 168 seeds of some equally unknown euphorbiaceous plant." — Millspaugh.

Iris yellow; bill black; feet and legs red.

PODICIPEDIDAE.

13. Colymbus podiceps Linné.

Pied-billed Grebe.

One specimen: ♂, Great Cenote, Chichen-Itza, Feb. 19, 1904.

Stone (Proc. Acad. Nat. Sci. Phila., 1890, 1891, p. 202) saw several birds which he supposed to belong to this species swimming in the aguada at Schkolak, but obtained no specimens.

CHARADRIIDAE.

14. Aegialitis vocifera (Linné).

Kildeer.

One was heard on February 22; saw and heard one March 7; heard one March 27. Mr. Thompson, Sr., told me that a short time before I came to

Chichen he quite often saw "a kind of plover" in the corral. These were very likely Killdeer. Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 203) took one specimen at Progreso.

15. ? Gallinago delicata (Ord).

Wilson's Snipe.

In my notes I have the following: — March 8. Late this afternoon I saw a snipe fly into the corral. I caught only a glimpse of it and hurried for my gun, but the bird had gone before I could get back. It looked like a Wilson's Snipe, but I could not identify it with certainty.

ARDEIDAE.

16. [* Ardea herodias Linné. Great Blue Heron.]

17. Florida coerulea (Linné).

Little Blue Heron.

One specimen: ♂ (white plumage), Progreso, Feb. 3, 1904.

A little Blue Heron in the adult plumage was shot by an Indian boy at Chichen on March 24, but its skin was not saved. Abundant in the Mangrove swamp back of Progreso. Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 203) observed one on the aguada at S[c]hkolak.

18. Canchroma zeledonia Ridgway.

Central American Boatbill.

In the Memorandum for the Ornithology of Yucatan Stephens (Incidents of Travel in Yucatan, 1843, **2**, p. 474) writes: "Of the genus Cancroma one specimen was procured, the cinereous boatbill, which was killed at the senote at Chichen." This bird is said to be common and very tame at Rio Lagartos (Boucard, Proc. Zool. Soc. Lond., 1883, p. 458).

ANATIDAE.

19. Querquedula discors (Linné).

Blue-winged Teal.

Maya name: The Indians at Chichen knew no name for this bird but the Spanish word *pato*, meaning "duck."

One specimen: ♂, Feb. 23, 1904.

Two Blue-winged Teal were seen at the Great Cenote on the above date, and this specimen was secured.

PLOTIDAE.

20. Anhinga anhinga (Linné)

Anhinga, Snake Bird.

One specimen: plumage of ♂, June 18, 1904, E. H. Thompson.

Mr. Thompson took this specimen of Anhinga at the Sacred Cenote and sent

the skin to the Museum of Comparative Zoölogy. The species has been reported at Progreso by Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 203).

PELECANIDAE.

21. Pelecanus fuscus Linné.

Brown Pelican.

One was shot by the Indian boys on February 26 from a large tree not far from the house.

CATHARTIDAE.

22. *Catharista urubu (Vieillot).

Black Vulture.

Maya name, *tṣōm;* Spanish, *sapilote.*

Chapman found the Black Vulture "somewhat less numerous than the Turkey Vulture," and of the latter he saw only three or four daily. During my stay at Chichen there were large numbers of Black Vultures in the neighborhood of the hacienda at nearly all times. They roosted at night in the large *pitš* trees, and spent much of the day on the ruins of an old church, where they often presented a curious spectacle as they stood with spread wings after a shower. On February 29 forty-five Vultures were counted in the vicinity at one time. They were awaiting their turn at the carcass of a pig lying in one of the corrals and being devoured by two large, ravenous dogs. While one dog feasted the other stood guard, running at and driving away any of the birds that approached too near. When the dogs sighted me they slunk away, and the Vultures immediately pounced upon the carcass. Heretofore the only note I had heard from these birds was a low grunt which they give as they take wing from the ground, but as they were crowding and flapping around the pig, fighting and pushing one another away, I heard them utter a different note, which sounded more like a *squawk.*

On March 5, at the Sacred Cenote, two old Vultures were seen feeding a young one. The young bird was in one of the shelf-like caves about half-way down the vertical wall of the cenote. It was fully half-grown, but still in the down; body brown, head black. Most of the time it remained back out of sight, but came out into view to be fed. On March 15 the young bird stayed out in sight much of the time. It did not seem to have changed much in appearance since it was first seen on March 5.

Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 204) reports finding a nest containing eggs of this species near Tekanto about February 15.

23. [*Cathartes aura (Linné.)

Turkey Vulture.

Maya name, *tšak-pul-tṣōm. Tšak* = red.

Chapman states that he saw three or four Turkey Vultures daily. I often made careful investigation of the Vultures at Chichen, but did not observe this

species there at all. My remembrance is, however, although I find no mention of it in my notes, that both species were observed at Progreso. Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 204) says the Turkey Vulture was occasionally seen by him in Yucatan, but was nowhere common.]

FALCONIDAE.

24. Micrastur melanoleucus (Vieillot)

Maya name, *kŏs* or *ēk-pīp*.
One specimen: ♀, March 1, 1904.
Not uncommon. Usually seen in the vicinity of the cenotes.

25. Asturina plagiata Schlegel.

Gray Buzzard-Hawk.
Maya name, *ī-kŏs*.
Two specimens:
a. ♂, March 24, 1904.
b. ♀, April 1, 1904.
Not uncommon.
Iris dark.

26. *Rupornis ruficauda griseicauda Ridgway.

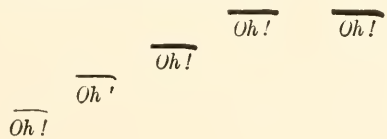
Rupornis ruficauda (Scl. & Salv.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 286.

Yucatan Gray-tailed Hawk.
Maya name, *kan-ī-kŏs*. *Kan* = yellow.
Two specimens:
a. ♀, March 28, 1904.
b. ♂, San Ignacio, Feb. 9, 1904.
Like Chapman, I found this hawk not uncommon.
Iris lemon yellow.

27. *Herpetotheres cachinnans (Linné).

Crying Hawk.
Maya name, *kŏs*.

Heard nearly every morning and evening in several directions. Sometimes heard before daylight in the morning and after dusk at night. The usual note is a rather drawn-out cry, much like the human voice in distress; it sounds like "Oh!" at a rather high pitch, and with a slightly falling inflection at the end. This is repeated at short intervals. Occasionally it gives a series of these cries, increasing in pitch and volume somewhat, and becoming slower as it proceeds. It may be represented roughly as follows: —



Stephens (Incidents of Travel in Yucatan, 1843, **2**, p. 470), mentions the taking of this hawk, which he calls the Laughing Falcon, at Chichen by Dr. Cabot, in 1842.

28. *Falco albigularis Daudin.

Falco rufigularis (Daud.). Chapman, Bull. Amer. Mus. Nat. Hist. 1896, **8**, p. 286.

White-throated Falcon.

Maya name, *qī-līs*.

Five specimens:

a. ♀, March 1, 1904.
b. ♀, March 8, 1904.
c. ♂, March 8, 1904.
d. (alcoholic), 1904.
e. Chichen-Itza, 189–, E. H. Thompson.

Two or three of these beautiful little hawks were commonly to be seen about the Sacred Cenote or in the nearby *milpas*. On March 1, Mr. Thompson observed a pair of them mating, but the ova of a female taken that day were still small. In the fresh specimen the skin in front of the eye is orange; the cere is near to chrome yellow.

29. *Cerchneis sparveria (Linné).

Sparrow Hawk.

Maya name, *ī-kŏs*.

Three specimens:

a. ♀ (?), March 19, 1904.
b. (alcoholic), 1904.
c. ♀, San Ignacio, Feb. 9, 1904.

One or more were seen or heard nearly every day.

BUBONIDAE.

30. Asio magellanicus mayensis (Nelson).

Bubo virginianus mayensis Nelson, Proc. Biol. Soc. Wash., 1901, **14**, p. 170.

Yucatan Horned Owl.

Maya name, *tun-ku-lu-tšu*.

Often, especially in the early part of the night, I heard owls hooting, which I think certainly must have been the Yucatan Horned Owl. The note was a loud *hoo-oo-oo, hoo, hoo*. I was unable to obtain any specimens. Mr. Thompson said that he had seen the bird, and that it looked like the Great Horned Owl (*Bubo virginianus*). This bird is known from only the type specimen collected at Chichen-Itza by Nelson and Goldman in 1901.

31. Otus[1] choliba[2] thompsoni,[3] subsp. nov.

Yucatan Screech Owl.

Maya name, *qō'-a-qab'* (means "night talker").

Type.—No. 40099, ♂ ad., Mus. Comp. Zoöl. Chichen-Itza, Yucatan. March 29, 1904. Leon J. Cole.

Co-type.—♀, Chichen-Itza, 1890, E. H. Thompson (Pablo Perera).

Subspecific characters.—Smaller than *O. choliba*, with greater amount of yellowish buffy suffusion, especially on head and neck, and with coarser black markings on under parts.

Description.—Upper parts similar to *O. choliba*, but with a less reddish cast, and more of a light yellowish or creamy buffy suffusion; fuscous markings on shafts of feathers broader, and broken transverse bars coarser and farther apart.

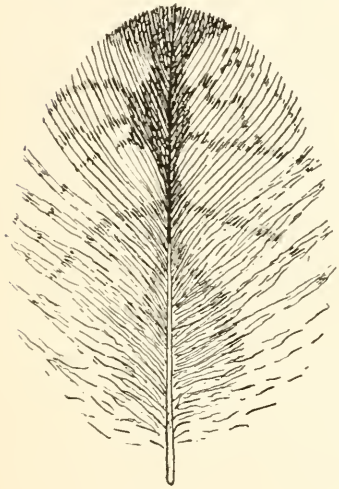


Fig. *B*.

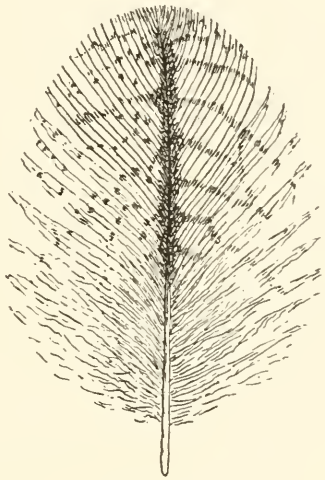


Fig. *C*.

Under parts: Throat suffused with creamy buff; feathers of breast and belly, as on back, with broader central markings, and with coarse and less broken bars. Figure *B* shows a feather from the breast of the type specimen, while Figure *C* represents one of the broadest-streaked feathers from a similar place from a specimen of *O. choliba* taken at Divala, Panama (Coll. E. A. & O. Bangs, No. 7743, ♂ ad., Dec. 11, 1900.) The large markings of these feathers, especially

[1] *Cf.* Stone, Auk, 1903, **20**, p. 272.

[2] It appears that the specific name *choliba* should supersede *brazilianus* (see note by Count von Berlepsch, Bull. Brit. Ornith. Club, 1901, **12**, p. 6).

[3] Named for Mr. E. H. Thompson, United States Consul to Yucatan.

on the breast, are a rich, dark fuscous, edged rather broadly with umber. Lower belly tinged with buffy, giving a richer appearance than that of *O. choliba*. The general tone of the under parts is light, however, *choliba* being more grayish.

Measurements of type.—Wing, 158 mm.; tail, 192; culmen (from base), 20; (from cere), 13; tarsus, 32.

Gray phase.—The specimen described above appears to represent the red phase of this bird, while the gray phase is represented in the specimen taken by a native collector, Pablo Perera, for Mr. E. H. Thompson, at Chichen-Itza in 1890, and marked on the label as a female. This specimen resembles very closely the type, except in lacking, for the most part, the buffy suffusion, and in having a finer reticulation (consisting of more transverse fuscous bars) of the under parts. Measurements: wing, 160 mm.; tail, 84; culmen (from base), 22; (from cere), 13; tarsus, 37.

The single specimen of this owl which I obtained was brought to me by one of the Indians, so that I am unable to give any further notes regarding it. It has been described as new only after having been compared carefully with specimens of *O. choliba* in the U. S. National Museum by Mr. E. W. Nelson, and with a small series in the collection of Messrs E. A. and O. Bangs, by Mr. Outram Bangs and myself. There appears to be more or less of a gradation of the birds of this species in passing from Brazil to southern Mexico. Two specimens in the Bangs collection, from Costa Rica, approach most closely to the Yucatan birds, but lack the clearness of the white which appears in the under parts of the latter.

Salvin and Godman (Biol. Centr.-Amer., **3**, p. 21) report a specimen of "*Scops guatemalae* (which they make synonymous with *Megascops brazilianus* = *O. choliba*) collected by Dr. G. F. Gaumer at Tizimin, Yucatan. It seems reasonable to suppose that this specimen belongs to the Yucatan race, although *Otus guatemalae*, which is undoubtedly distinct from *Otus choliba*, and in a large part co-extensive with it, may really extend northward into the peninsula.

32. *Glaucidium phalaenoides ridgwayi (Sharpe).

Ridgway's Ferruginous Pigmy Owl.

Maya name, *tŏ'-ka-šnuk'*. Literally *tŏ'-ka* means one who picks or pecks stone, *šnuk* is an old woman — the "old woman stone picker." The stones (*metatl*, Mexican; *ka*, Maya) on which corn for *tortillas* is ground are usually roughened by the old women, and the name *tŏ'-ka-šnuk'* is applied to this little owl because its note is supposed to resemble the sound made in the operation.

Three specimens:

a. ♂, Feb. 18, 1904.
b. ♂, March 7, 1904.
c. (alcoholic), 1904.

Common. Apparently largely diurnal in habits. Turns the head with a jerky motion, and also jerks the tail at short intervals. Iris, light yellow.

STRIGIDAE.

33. Strix pratincola Bonaparte.

American Barn Owl.

Maya name, *šotš*.

This species is included in this list entirely upon the authority of Mr. Thompson, who tells me that Barn Owls are sometimes found in the ruins.

PSITTACIDAE.

34. *Conurus aztec Souancé.

Aztec Paroquet.

Maya name, *qa-lī'*. Means "noisy bird."

Three specimens:

a. ♂, Feb. 28, 1904.
b. Chichen-Itza, 189–, E. H. Thompson.
c. ♀, San Ignacio, Feb. 9, 1904.

Abundant. Seen especially mornings and evenings, flying over in small flocks of two or three to several individuals.

35. *Amazona albifrons nana W. DeW. Miller.

Bull. Amer. Mus. Nat. Hist., 1905, **21**, p. 349.

Yucatan White-fronted Parrot.

Maya name, *ţuut*.

Three specimens:

a. ♂, March 8, 1904.
b. sex? (skinned from formalin), 1904.
c. Chichen-Itza, 189–, E. H. Thompson.

Small flocks were frequently seen, usually flying rapidly over at morning or evening. The largest single flock observed was composed of 14 birds.

Iris, light straw color.

The craw of the male taken on March 8 was filled with the cotyledons of a leguminous plant which Mr. Millspaugh determined as *Cassia* sp. The bird apparently split the seeds and removed the outer coating before swallowing the cotyledons.

Waldron DeWitt Miller has recently renamed the Yucatan White-fronted Parrot on the ground that it is smaller than the typical *A. albifrons*, with a proportionately larger bill, and more *yellowish* green in color. My birds do not altogether bear out Miller's conclusions, in fact, in measurements they occupy an intermediate position, while the smallest birds I have examined, and the only ones as small as those recorded from Yucatan by Miller, are two specimens in the Bangs collection, from Guatemala. Another specimen taken

farther south, on the boundary between Nicaragua and Honduras, is fully as large as the birds from Yucatan. It is rather hazardous to place much dependence upon size in parrots, but since I have not had opportunity to compare my specimens in other respects with undoubted typical *albifrons* from farther north in Mexico, I have adopted the new subspecific name for the Yucatan birds. It seems not unlikely that the species averages smaller and more yellowish to the southward, though this condition is apparently not limited to the Yucatan peninsula. *A. albifrons saltuensis* Nelson is distinctly different from any other representatives of the species I have had opportunity to examine.

MOMOTIDAE.

36. *Eumomota superciliaris (Swainson).

Red-backed Motmot.

Maya name, *tŏh*.

Two specimens:

a. ♂, Feb. 19, 1904.

b. ♂, March 14, 1904.

These beautiful birds were common, especially about the Sacred Cenote and some of the ancient ruins, particularly the House of the Nuns and the adjacent buildings, where they roosted in the holes in the masonry. At one time several were brought to me alive which had been easily captured in these holes. The time of my visit appeared to be before the nesting season; nevertheless the birds were at times very noisy, their note, which is suggested by the Maya name, being a characteristic sound for the Yucatan forest. Besides the repetition of the single note *tŏh* (or *kwau*, as I have it represented in my notes — the *au* having the sound of *a* in *awl*) they sometimes give a series of notes — *kwau-ka-wa'*, *kwau-ka-wa'*, *kwau-ka-wa'* — which also has more or less variation.[1] They fly with small undulations.

CAPRIMULGIDAE.

37. Chordeiles acutipennis texensis (Lawrence).

Texan Nighthawk.

One specimen: ♂, April 2, 1904.

This bird has been taken at a number of places in Yucatan, but has not previously been reported from Chichen-Itza.

[1] Mr. Thompson says he has recently heard another note of the Motmot — a low, semi-musical series of four notes. The Indians told him it was the *tŏh* that made these notes, but he did not think it could be until he later verified the matter for himself. Sept. 24, 1905.

38. *Nyctidromus albicollis yucatanensis Nelson.

Proc. Biol. Soc. Wash., 1901, **14**, p. 171.

Nyctidromus albicollis merrilli Senn. Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 285.

Yucatan Parauque.

Maya name, *pu-hui*. Said to be an evil spirit that is supposed to swoop down at night and carry people away.

Three specimens:

a. ♂, March 10, 1904.

b. Chichen-Itza, Feb. 5, 1890, E. H. Thompson (Pablo Perera).

c. Chichen-Itza, 189–, E. H. Thompson.

Nelson has recently described the Yucatan Parauque as distinct from Merrill's Parauque (*N. a. merrilli* Senn.), which Chapman considered the Yucatan form to be. Dr. Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 451) states that this is the "most common of all the Caprimulgidae in Yucatan."

The testes of the male procured by me were very much enlarged (left testis measured 16 mm. × 8 mm.). This would seem to indicate that it was near the breeding season for this bird.

39. Nyctagreus yucatanicus (Hartert) Nelson.

Proc. Biol. Soc. Wash., 1901, **14**, p. 171.

Caprimulgus yucatanicus Hartert, Cat. Birds Brit. Mus., 1892, **16**, p. 575.

One specimen: ♀, March 18, 1904.

So far as I am aware, there is but one previous record of this bird from Yucatan, and that a female taken by Dr. Gaumer on June 10, 1879. On account of the "pure white band across the throat and the white tips to the outer tail-feathers, so frequently characteristic of the male in Caprimulgidae" Salvin and Godman (Biol. Centr.-Amer., **2**, p. 388) were led to doubt whether the sex of this specimen was properly determined. My bird, however, which was undoubtedly a female, possessed these same markings.

40. Antrostomus salvini (Hartert).

Mexican Whippoorwill.

One specimen: ♂, March 29, 1904.

Stated by Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 451) to be "very common in Merida." Nelson (Proc. Biol. Soc. Wash., 1905, **18**, p. 112) has published the measurements of this specimen as follows: Wing, 176; tail, 130; culmen, 14; tarsus, 18.

CYPSELIDAE.

41. Chaetura gaumeri Lawrence.

Gaumer's Chimney Swift.

Maya name, *kū-sam*.

Three specimens:

a. ♀ March 19, 1904.
b. ♀ March 19, 1904.
c. ♀ March 19, 1904.

Chimney Swifts were first noticed on March 16 and 17, when a number were seen flying about near the house. More were observed on the 19th. They were abundant in the late afternoon, and at about sunset they filed gradually into the vertical well-shaft to roost. On the 19th one of the Indians went down in the well after dark with a lantern and obtained several specimens. The birds were not seen about again until the 23d, and I have no record of them after that date. The note impressed me as rather less loud and harsh than that of *Chaetura pelagica*.

TROCHILIDAE.

42. [*Amazilia yucatanensis (Cabot). Cabot's Hummingbird.]

43. *Amazilia cinnamonea (Lesson).

Cinnamon Hummingbird.
Maya name, *ẓū-nūn*.
One specimen: sex ?, March 29, 1904.

44. *Chlorostilbon caniveti (Lesson).

Canivet's Hummingbird.
One specimen: sex ?, April 7, 1904.

45. [*Lampornis prevosti (Lesson). Prevost's Hummingbird.]

46. Trochilus colubris Linné.

Ruby-throated Hummingbird.
Maya name, *ẓū-nūn*.
Five specimens:

a. ♂, Feb. 4, 1904.
b. [♀], March 23, 1904.
c. [♂], March 25, 1904.
d. [♂], March 27, 1904.
e. [♀], April 5, 1904.

Common. Most of the Hummingbirds seen were of this species.

TROGONIDAE.

47. Trogon puella Gould.

Rayed-tailed Trogon.
Three specimens:

a, b. [♀ ♀], Chichen-Itza, 189–. E. H. Thompson
c. [♂], Chichen-Itza, 189–. E. H. Thompson.

Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 454) reports this Trogon as very rare in Yucatan.

48. Trogon melanocephalus Gould.

Black-headed Trogon.

Maya name, *kuš-tīn*.

Five specimens:

a. ♀, March 19, 1904.

b. ♂, March 23, 1904.

c–e. Chichen-Itza, 189–, E. H. Thompson.

The yellow on the ventral parts of the specimens taken by me is decidedly paler than in examples from Mexico and Central America with which they were compared, and the white band below the black of the breast is rather broader. The three birds from the Thompson collection, however, are typical. It is possible that the differences noted above may be seasonal, but as the Thompson birds bear no date this cannot be determined from the specimens in hand.

Eye-lids of recently killed bird, light azure blue.

49. Trogon caligatus Gould.

Booted Trogon.

Maya name, *kuš-tīn*.

Six specimens:

a. ♀, March 5, 1904.

b. [♂], March 18, 1904.

c–f. Chichen-Itza, 189–, E. H. Thompson.

Occasionally seen around the Great Cenote.

CUCULIDAE.

50. Piaya cayana thermophila (Sclater).

Long-tailed Cuckoo.

Maya name, *kīṗ-tšo'*.

Four specimens:

a. ♂ (?), Feb. 28, 1904.

b. ♂ (?) March 4, 1904.

c. (alcoholic), 1904.

d. Chichen-Itza, 189–, E. H. Thompson.

Not uncommon. I am surprised that Chapman did not note this bird.

Iris red.

51. Geococcyx affinis Hartlaub.

Mexican Road runner.

Maya name, *kūm-kūmīl*. "'Xcum-kumil' is its name in Western Yucatan; in the East the Indians call it 'Bochen-choo-lool,'" Boucard, Proc. Zool. Soc. Lond., 1883, p. 454.

One specimen: ♂, Yucatan (Xbac?), 1901, G. F. Gaumer.

I include this bird in the list for Chichen-Itza on the authority of Mr. Thompson, who knows the bird well and has seen it there. Dr. Gaumer kindly presented me with a specimen taken by his collector, presumably at Xbac.

52. *Crotophaga sulcirostris Swainson.

Groove-billed Ani.

Maya name, *tšik-bul.*

Two specimens:

a. ♀, Feb. 20, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

Abundant, especially about the yard and corrals. This species was seen at San Ignacio, also, but was not observed at Progreso, although it is reported from there by Stone (Proc. Acad. Nat. Sci. Phila., 1891, 1890, p. 205).

RHAMPHOSTIDAE.

53. Pteroglossus torquatus (Gmelin).

Collared Toucon.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

PICIDAE.

54. *Melanerpes dubius (Cabot).

Uxmal Woodpecker.

Maya name, *tše-hot* or *tše-hom.*

Four specimens:

a. ♀, Feb. 20, 1904.

b. (alcoholic), March 6, 1904.

c. d. Chichen-Itza, 189–, E. H. Thompson.

Rather common. Note a complaining *chick-r-r-r, chick-r-r-r.*

55. *Melanerpes rubiventris (Swainson).

Swainson's Woodpecker.

Three specimens:

a, b. Chichen-Itza, 189–, E. H. Thompson.

c. Yucatan (Xbac?), 1901, G. F. Gaumer.

Chapman found this Woodpecker "tolerably common" at Chichen, but I did not see it there.

56. [*Dryobates scalaris parvus Ridgway. Cabot's Woodpecker.]

57. Veniliornis caboti (Malherbe).

Chloronerpes oleagineus (Licht.). Boucard, Proc. Zool. Soc. Lond., 1883, p. 452.
Dendrobates caboti (Malh.). Salvin and Godman, Biol. Centr.-Amer., **2**, p. 438.

Maya name, *tše-hot;* also called *tši-piš.*

One specimen: ♀, March 13, 1904.

Not common; Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 452) gives it as "very rare" in Yucatan. In the specimen taken by me the under side of the wings is unspotted, a condition which Mr. Nelson thinks is due to immaturity.

58. *Ceophloeus scapularis (Vigors).

Delattre's Woodpecker.

Maya name, *ko-lon-te'*. Means "master carpenter"; so called because the largest.

One specimen: ♂, March 23, 1904.

Not uncommon. Iris white.

FORMICARIIDAE.

59. *Thamnophilus doliatus mexicanus Allen.

Mexican Ant-thrush.

Maya name, *ta-ta-tšēl*. This name appears to be applied only to the female; the same name is given to Sittasomus and Dendrornis.

Three specimens:

a. ♂, March 11, 1904.

b. ♀, March 12, 1904.

c. sex ?, Yucatan (Xbac ?), 1901, G. F. Gaumer.

Like Chapman I found this bird not common. Iris of male yellowish; not noted in the female.

DENDROCOLAPTIDAE.

60. Synallaxis erythrothorax Sclater.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 449) gives the Maya name of this bird as "Tzapatan" (*ɔa-pa-tan*).

61. *Dendrocincla anabatina typhla Oberholser

Proc. Acad. Nat. Sci. Phila., 1904, p. 452.

Wood Hewer.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

The marked paleness of this specimen was noticed before it was compared with Oberholser's description of the subspecies. It would appear to be a characteristic condition of the Yucatan birds.

62. *Dendrocincla homochroa (Sclater). Wood Hewer.

63. Sittasomus sylvoides Lafresnaye.

Maya name, *ta-ta-tšēl*. Refers to its working about wood; the *ta-ta* is in imitation of the tapping sound made with the bill.

Two specimens:

a. ♀, March 23, 1904.

b. Chichen-Itza, Feb. 5, 1890, E. H. Thompson (Pablo Perera).

Not common. The specimen taken by me appeared to be rather small and pale, but Mr. Nelson, who examined it, writes: "A number of specimens of Sittosomus in our collection from Yucatan show that the birds from that region are not distinguishable from those from elsewhere in Mexico." Specimen *b* agrees with my specimen in coloration, but is a little larger.

64. *Dendrornis flavigastra (Swainson).

Wood Hewer.

Maya name, *ta-ta-tšēl*.

Five specimens:

a. ♂, Feb. 18, 1904.

b–e. Chichen-Itza, 189–, E. H. Thompson.

Chapman reports this bird as "tolerably common," but I found it rather scarce.

TYRANNIDAE.

65. Rhynchocyclus cinereiceps (Sclater).

One specimen: ♀, March 23, 1904.

66. *Myiozetetes similis superciliosus (Bonaparte).

Myiozetetes texensis (Giraud). Chapman, Bull. Amer. Mus. Nat. Hist, 1896, **8**, p. 283.

Maya name, *ta-kaï'*.

Two specimens:

a. ♂, March 13, 1904.

b. ♂, March 23, 1904.

67. *Megarhynchus pitangua mexicanus (Lafresnaye).

Megarhynchus pitangua (Linné). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 283.

Mexican Large-billed Tyrant.

Maya name: Boucard (Proc. Zool. Soc. Lond., 1883, p. 448) gives the Maya name of this bird as "Stachi." Without the feminine prefix it should probably be written *ta-tšaï'* or *ta-kaï'*.

Two specimens:

a. ♂, March 14, 1904.

b. Chichen-Itza, 189–, E. H. Thompson

Rather common near the Sacred Cenote.

68. *Empidonax minimus (W. M. and S. F. Baird).

Least Flycatcher.

Two specimens:

a. ♂, Feb. 16, 1904.

b. ♂, April 5, 1904.

Frequently seen and occasionally heard.

69. [*Contopus brachytarsus (Sclater). Short-legged Pewee.]

70. Blacicus depressirostris (Ridgway).

One specimen: ♂, April 5, 1904.

71. [*Myiarchus cinerascens (Lawrence). Ash-throated Flycatcher.]

72. *Myiarchus yucatanensis Lawrence.

Yucatan Crested Flycatcher.

Maya name, *ī'-a.*

Two specimens:

a. ♂, Feb. 18, 1904.

b. sex ?, March 9, 1904.

73. *Tyrannus melancholicus couchi (Baird).

Tyrannus melancholicus Vieill. Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 284.

Couch's Kingbird.

Maya name, *ta-kaï'*. Given as "Stachi" by Boucard (Proc. Zool. Soc. Lond., 1883, p. 448.)

Two specimens:

a. ♂, Feb. 22, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

This bird has a note which reminds one somewhat of the *chip, chip* of a song-sparrow, but it is not so harsh.

COTINGIDAE.

74. *Tityra semifasciata (Spix).

Tityra personata Jardine & Selby. Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 284.

Mexican Tityra.

Maya name, *pē-lan-qē-wel.*

Four specimens:

a. ♂, Feb. 26, 1904.
b. (alcoholic), 1904.
c, d. Chichen-Itza, 189–, E. H. Thompson.

Rather common in the large trees in the clearing near the house.

75. Platypsaris aglaiae (Lafresnaye).

Rose-throated Becard.

Maya name, *ī'-a*.

Two specimens:

a. ♀ (?), March 12, 1904.
b. ♂, March 14, 1904.

76. Pachyrhamphus major itzensis Nelson.

Proc. Biol. Soc. Wash., 1901, **14**, p. 173.

Yucatan Pachyrhamphus.

Two specimens:

a. ♂, March 13, 1904.
b. ♂, Feb. 5, 1890, E. H. Thompson (Pablo Perera).

Apparently rare; but the one specimen seen by me. The subspecies was described from a female taken at Chichen-Itza by Nelson and Goldman.

HIRUNDINIDAE.

77. Progne chalybea chalybea (Gmelin).

Gray-breasted Martin.

Maya name, *kū-sam'*; also *ī-ya'*. "When anything comes near them they circle about it crying '*ī-ya'*, *ī-ya'*,' meaning 'Look out! Look out!'"

Two specimens:

a. ♂, March 4, 1904.
b. ♀, March 4, 1904.

A few of these birds were seen about in the neighborhood of the house in the early part of March. They often flew into holes under the veranda roof to roost.

78. *Stelgidopteryx ridgwayi Nelson.

Stelgidopteryx serripennis (Aud.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 278.

Maya name, *kū-sam'*.

One specimen: sex ?, Feb. 22, 1904.

Like Chapman, I found these birds abundant about the ruins.

MUSCICAPIDAE.

79. *Polioptila caerulea mexicana (Bonaparte).

Polioptila caerulea (Linné). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 276.

Mexican Gnatcatcher.

Maya name: I did not learn any native name for the Gnatcatcher at Chichen-Itza. Mr. Thompson tells me that at Ticul it is called *ɔ̈ī-ẓīl*.

The gnatcatchers which were heard and seen commonly during the whole of my stay at Chichen are probably to be referred to this subspecies. Mr. Bangs states, however, that he believes both *P. caerulea mexicana* and *P. caerulea caerulea* may occur in Yucatan. He has in his collection a fine skin of true *P. c. caerulea* from there identified by Mr. Nelson. Such being the case, it is possible that Chapman's record should not be included under the subspecies *mexicana*.

TROGLODYTIDAE.

80. *Pheugopedius maculipectus cano-brunneus (Ridgway).

Yucatan Spotted-breasted Wren.

Maya name, *pō-kīm'*.

Two specimens:

a. ♂, Feb. 26, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

Rather common.

81. *Thryomanes albinucha (Cabot).

Cabot's Wren.

Maya name, *pō-kĭm'*; also *yam-kō-tīl'*. This second name was also applied to warblers and other inconspicuous small birds.

One specimen: sex ?, Feb. 28, 1904.

Common.

82. *Nannorchilus leucogaster brachyurus (Lawrence).

Hemiura brevicauda (Lawr.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 277.

Temax Wren.

Maya name, *tš-hōt'*.

One specimen: ♀, Feb. 18, 1904.

Common. I occasionally heard a song much like that of *Troglodytes aëdon*, which, from Chapman's remarks, I attribute to this bird.

TURDIDAE.

83. Merula grayi (Bonaparte).

Gray's Thrush.

Maya name, *qōq*. Spanish name, *Ruiseñor*.

Two specimens:

a. ♂, March 31, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

Iris reddish brown.

The only specimen of this bird observed was taken at about sunset, when it was singing a varied song, somewhat resembling that of the Brown Thrasher; not loud, but very pretty. Gaumer stated in his notes published by Boucard (Proc. Zool. Soc. Lond., 1883, p. 439): "It utters no cry when approached, and is said to sing only in June. Though I have spent the summer in Yucatan, I have never had the pleasure of hearing this bird sing." Mr. Thompson confirms his statement that it is often kept as a cage-bird, and adds that it tames easily and breeds in confinement.

VIREONIDAE.

84. Vireosylva olivacea (Linné).

Red-eyed Vireo.

One heard singing on April 3.

85. Vireosylva flavoviridis flavoviridis Cassin.

Yellow-green Vireo.

One specimen: ♂, April 3, 1904.

Iris red.

86. *Lanivireo flavifrons (Vieillot).

Yellow-throated Vireo.

One specimen: ♀, Feb. 18, 1904.

This was the only example of this species noted.

87. *Vireo noveboracensis noveboracensis (Gmelin).

White-eyed Vireo.

Three specimens:

a. ♂, March 6, 1904.

b. (alcoholic), 1904.

c. Chichen-Itza, 189–, E. H. Thompson.

The male taken on March 6 was singing.

88. *Vireo ochraceus Salvin.

Ochraceus Vireo.

Two specimens:

a. ♀, March 23, 1904.

b. ♂, April 7, 1904.

Iris brown.

An Indian working about the yard brought me, on April 7, the male bird recorded above, which he had caught on the nest. The latter, which is deeply

cupped, was situated about 0.5 m. from the ground in a lime hedge, hung in a small crotch. It much resembles in appearance the nest of *Vireosylva olivacea;* rather compactly constructed of small dead leaves, dried grass, and other vegetable fibres, and lined with very fine grass. There are also in the outer part a few pieces of moss and one or two small fungi, while some web-like material appears to have been used to bind the other constituents together. Internal diameter at top 4 cm. × 4.5 cm., somewhat larger below; depth of cup 4 cm.; thickness of walls nearly 1 cm. This nest contained three eggs, which were saved, but cannot now be found. My remembrance of them is that they were white with brownish markings, much resembling the eggs of *Vireo noveboracensis.* Small embryos were already formed at the time they were taken.

89. *Cyclarhis flaviventris yucatanensis Ridgway.

Yucatan Pepper-shrike.

One specimen: ♂, March 30, 1904.

The beautiful clear song of this bird was quite frequently heard.

CORVIDAE.

90. *Cissolopha yucatanica (Dubois).

Yucatan Jay.

Maya name, *tṣeel* ("Chel," Boucard, Proc. Zool. Soc. Lond., 1883, p. 446).

Six specimens:

a. ♀, Feb. 15, 1904.
b. ♂, April 3, 1904.
c–f. Chichen-Itza, 189–, E. H. Thompson.

Abundant, usually in large flocks. Their habits, when approached, are well described by Gaumer (Boucard, Proc. Zool. Soc. Lond., 1883, p. 446).

91. *Xanthoura luxuosa guatemalensis (Bonaparte).

Guatemalan Green Jay.

Maya name, *sĕ-sīp'*. "The natives call this bird 'jisip' (tzee-seep), which with the Maya pronunciation is exactly the word articulated by the bird." — Boucard, Proc. Zool. Soc. Lond., 1883, p. 447.

Four specimens:

a. ♂, March 7, 1904.
b, c. (alcoholic), 1904.
d. Chichen-Itza, 189–, E. H. Thompson.

Rather common. Iris, yellow; inside of mouth, black.

92. *Psilorhinus mexicanus vociferus (Cabot).

Yucatan Brown Jay.

Maya name, *paap.* From call note.

Two specimens:

a. ♀, March 8, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

My observations on the occurrence of this bird agree with Chapman's, viz., "Rather uncommon. It was found in pairs and trios in the woods, and was rather shy and suspicious."

MNIOTILTIDAE.

93. *Setophaga ruticilla (Linné).

American Redstart.

Two specimens:

a, b. Chichen-Itza, 189–, E. H. Thompson.

One seen February 18 in a flock of warblers along the road to Xmakaba.

94. *Wilsonia mitrata (Gmelin).

Sylvania mitrata (Gmel.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 278.

Hooded Warbler.

Four specimens:

a. (alcoholic), 1904.

b–d. Chichen-Itza, 189–, E. H. Thompson.

95. *Granatellus sallaei boucardi Ridgway.

Boucard's Red-breasted Chat.

Maya name, *tšak-sīn-kīn*. Means "red sun bird."

Three specimens:

a. ♂, March 14, 1904.

b. Chichen-Itza, 1890, E. H. Thompson (Pablo Perera).

c. Chichen-Itza, 189–, E. H. Thompson.

Apparently rare, as only one specimen was observed.

96. *Icteria virens virens (Linné).

Yellow-breasted Chat.

Two specimens:

a. (alcoholic), 1904.

b. ♂, Chichen-Itza, 1890, E. H. Thompson (Pablo Perera).

97. *Geothlypsis trichas brachidactyla (Swainson).

Geothlypsis trichas (Linné). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 277.

Northern Yellow-throat.

One seen in a *milpa* near the Sacred Cenote on February 27, and another along the Xmakaba road on February 28. No specimen was taken, but it is probable that these birds belonged to this subspecies (*cf.* Ridgway, Bull. 50, U. S. Nat. Mus., 1902, **2**, p. 665).

98. [*Seiurus aurocapillus (Linné.) Ovenbird].

99. Dendroica palmarum palmarum (Gmelin).

Palm Warbler.

One specimen: ♂, Feb. 22, 1904.

Gaumer reported this bird from Progreso (Boucard, Proc. Zool. Soc. Lond., 1883, p. 441), and in a note Salvin remarked that that was the first time it had been observed in Central America.

100. Dendroica dominica albilora Ridgway.

Sycamore Warbler.

Two specimens:

a. ♀, Feb. 25, 1904.

b. Chichen-Itza, 189–, E. H. Thompson.

My specimen was taken in an orange tree in the yard.

101. *Dendroica virens (Gmelin).

Black-throated Green Warbler.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

I observed two of these birds at the Sacred Cenote on February 14, and several in a scattered flock of miscellaneous warblers along the Xmakaba road on February 18.

102. Dendroica maculosa (Gmelin).

Magnolia Warbler.

One specimen: sex ?, Feb. 18, 1904.

From a flock of Warblers of various species. This bird has been taken by Gaumer at Izamal (Salvin and Godman, Biol. Centr.-Amer., **1**, p. 129).

103. Dendroica bryanti bryanti Ridgway.

Bryant's Yellow Warbler.

Two specimens:

a. ♂, March 23, 1904.

b. ♂, Progreso, 1904.

104. Compsothlypis americana ramalinae Ridgway.[1]

Western Parula Warbler.

One specimen: ♂, Feb. 18, 1904.

Shot from a flock of miscellaneous warblers.

105. *Mniotilta varia (Linné).

Black and White Warbler.

Two specimens:

[1] Mr. Bangs has in his collection a specimen of *C. a usneae* from Yucatan.

a. (alcoholic), March 13, 1904.
b. Chichen-Itza, 189–, E. H. Thompson.

A few individuals occasionally seen.

ICTERIDAE.

106. Icterus mesomelas mesomelas (Wagler).

Yellow-tailed Oriole.
One specimen : Chichen-Itza, 189–, E. H. Thompson.

107. *Icterus auratus Bonaparte.

Orange Oriole.
Maya name, *yū-yūm*. "Swinging bird."
One specimen : [♂], March 19, 1904.

108. *Icterus giraudii Cassin.

Giraud's Oriole.
Two specimens :
a, b. Chichen-Itza, 189–, E. H. Thompson.

Although I found orioles abundant at Chichen, I did not myself secure a specimen of this species. This was probably due to the difficulty of distinguishing the different species in the field, since *I. giraudii* would appear to be common there.

109. Icterus cucullatus igneus Ridgway.

Fiery Oriole.
Maya name, *yū-yūm*.
One specimen : ♂, Feb. 16, 1904.

110. *Icterus gularis yucatanensis Berlepsch.

Yucatan Oriole.
Maya name, *yū-yūm*.
Three specimens :
a. ♂ March 13, 1904.
b, c. Chichen-Itza, 189–, E. H. Thompson.

111. Icterus prosthemelas (Strickland).

Lesson's Oriole.
Maya name, *hom'-šan-īl'*, meaning "of the palms."
Two specimens :
a. ♀ (juv.), March 13, 1904.
b. Chichen-Itza, 189–, E. H. Thompson.

This appears to be the first record of this species from Yucatan.

112. *Dives dives (Lichtenstein).

Pueblo Blackbird.

Maya name, *pītš*. "Native name 'Pich' (pronounced 'peach')" — Boucard, Proc. Zool. Soc. Lond., 1883, p. 446.

One specimen: ♂, March 23, 1904.

Rather common about the hacienda.

113. Megaquiscalus major macrourus (Swainson)

Great-tailed Grackle.

Maya name, *qa͡a͡u*. "Native name 'Sacoa.' The female is considered by the natives another species and is called 'Socao,' instead of 'Sacoa.'" — Boucard, Proc. Zool. Soc. Lond., 1883, p. 446.

One specimen: ♀, April 1, 1904.

114 *Tangavius aeneus involucratus (Lesson)

Callothrus robustus (Cab.). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 280.

Red-eyed Cowbird.

Maya name, *ōīv*. From call note.

One specimen: ♂, March 4, 1904.

Abundant in the corrals, where they could often be seen climbing over the cattle, horses, and pigs in search of ticks. They sometimes sustain themselves suspended on the wing for a moment or so while they pick ticks from the legs or bellies of the cattle.

115. *Amblycercus holosericeus (Lichtenstein).

Prevost's Cacique.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

Chapman gives this species as tolerably common in and about the borders of the cornfields or *milpas*. I did not observe the bird, and the only specimen from Chichen I have examined is that recorded above.

TANAGRIDAE

116. Phoenicothraupis salvini peninsularis Ridgway.

Yucatan Ant Tanager.

Maya name, *ba-ka-lar'*.

Three specimens:

a. ♂, March 9, 1904.

b. [♀], March 9, 1904.

c. Chichen-Itza, 189–, E. H. Thompson.

117. [*Phoenicothraupis rubica nelsoni Ridgway.

Rosy Ant Tanager.

Phoenicothraupis rubicoides (Lafr.). Chapman, Bull Amer. Mus Nat Hist., 1896, **8**, p. 279.]

118. *Piranga roseo-gularis roseo-gularis Cabot.

Rose-throated Tanager.

Maya name, *ba-ka-lar'*.

Five specimens:

a. [♀], Feb. 18, 1904.
b. ♂, March 13, 1904.
c. ♀, March 13, 1904.
d. ♂, Chichen-Itza, Jan. 20, 1890, E. H. Thompson (Pablo Perera).
e. Chichen-Itza, 189–, E. H. Thompson.

119. *Euphonia hirundinacea Bonaparte.

Bonaparte's Euphonia.

Maya name, *tsīn-tšīn-bakal de capa*. The Spanish words *de capa* are added to the Maya name of this species by the Indians to denote the black crown.

Four specimens:

a. ♂, Feb. 20, 1904.
b. ♂, March 13, 1904.
c. ♀, March, 19, 1904.
d. Chichen-Itza, 189–, E. H. Thompson.

Usually keeps well to the tops of tall trees. Note a rather insect-like *chick-che-e-e-e*.

120. Euphonia affinis (Lesson).

Lesson's Euphonia.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

FRINGILLIDAE.

121. * Saltator atriceps atriceps Lesson.

Black-headed Saltator.

Maya name, *ta-pīn*.

Four specimens:

a. ♂, Feb. 27, 1904.
b. ♀, March 9, 1904.
c. ♂, Chichen-Itza, Feb. 10, 1890, E. H. Thompson (Pablo Perera).
d. Chichen-Itza, 189–, E. H. Thompson.

Apparently rather local, as I saw it only in one or two vicinities, not far from the house. Seems to prefer the lower growth on the borders of clearings.

122. *Cardinalis cardinalis yucatanicus Ridgway.

Yucatan Cardinal.

Maya name, *tšak-ɔī'-ɔī*. Means "red painted [bird]."

One specimen: ♀ (?), Feb. 22, 1904.

Common. Chapman says: "In notes and habits this subspecies resembles *C. cardinalis*, but its brighter coloration is evident even at a distance." My observations agree with his in regard to coloration, and so far as I could ascertain, also as to habits; but the song impressed me as markedly different from the clear ringing whistle of *C. cardinalis* as I am familiar with it in our northern States and in Bermuda. The note of the Yucatan bird seems to me to be harsher and less musical, and to be uttered rather more rapidly. In my note book I have it represented as follows:

— — ⌣ — — ⌣ ⁀ ⁀ ⁀ ⁀ ⁀

ch-ch-weé, ch-ch-weé (two to four times), *pleu, pleu, pleu, pleu, pleu* (five to eight times). There is much variation from this; for example, sometimes only the first three or four notes are given and not followed by the second part of the song.

123. Zamelodia ludoviciana (Linné).

Rose-breasted Grosbeak.

One specimen: (plumage of ♀) Chichen-Itza, 189–, E. H. Thompson.

124. Guiraca caerulea caerulea (Linné).

Blue Grosbeak.

One specimen: (plumage of ♂ in winter), Chichen-Itza, 189–, E. H. Thompson.

125. Cyanocompsa parellina parellina (Bonaparte).

Blue Bunting.

Six specimens:

a. ♂, Chichen-Itza, 1890, E. H. Thompson (Pablo Perera).

b–e. (2 in plumage of ♂, 2 in plumage of ♀), Chichen-Itza, 189–, E. H. Thompson.

f. (plumage of ♂), Xbac (?), 1901, G. F. Gaumer.

126. * Cyanospiza ciris (Linné).

Passerina ciris (Linné). Chapman, Bull. Amer. Mus. Nat. Hist., 1896, **8**, p. 279.

Nonpareil; Painted Bunting.

One specimen: Chichen-Itza, 189–, E. H. Thompson.

127. * Arremonops verticalis Ridgway.

Arremonops rufivirgata striaticeps Ridgw. Chapman, Bull, Amer. Mus. Nat. Hist., 1896, **8**, p. 280.

Schott's Sparrow.

One specimen: ♂, March 19, 1904.

Chapman reports this bird as abundant and "generally distributed in the undergrowth about the borders of clearings, where they pass much of their time on the ground." I found the bird not uncommon, but hardly abundant,

and from the fact that I frequently heard the song in a few definite localities, I judged that the birds might be nesting. They were heard singing as early as March 6, and were still in song when I left, early in April. As Chapman says, the song suggests that of the Field Sparrow. It differs, however, not only in quality, but in keeping about on the same note, and in decreasing but little in volume, though it becomes much more rapid towards the end. It may be represented by the syllables: *chew——chew——chew——chew—che-che-che-che-che-che-che*. When one is close to the singer, a sharp preliminary note may sometimes be heard, thus: *chip, chew——chew——*etc. There appears to be considerable variation in the song of the same individual. The song is usually heard in the early part of the forenoon.

128. Pooecetes gramineus gramineus (Gmelin).

Vesper Sparrow.

One specimen: ♀, April 4, 1904.

So far as I can learn, the Vesper Sparrow has not previously been reported from Yucatan; in fact, this appears to be the extreme southern record for this subspecies, since Salvin and Godman (Biol. Centr.-Amer., **1**, p. 383) state that the bird which occurs in Mexico is the western subspecies, *P. g. confinis*. Ridgway (Bull. 50, U. S. Nat. Mus., 1901, **1**, p. 183) says that it goes "south in winter to Gulf coast (Florida to eastern Texas)." This record is the more remarkable for the lateness in the season when the specimen was taken, the species usually being by that time well north on its spring migration.

The identification of this bird was kindly verified by Mr. Ridgway.

ADDITIONAL LIST OF BIRDS FROM YUCATAN WHICH HAVE NOT AS YET BEEN REPORTED FROM CHICHEN-ITZA.

This list, included for the sake of making complete the report on the birds obtained, contains merely notes on a few species obtained or observed in other parts of the peninsula, and not included in the foregoing list.

1. Tinamus robustus Sclater.

Tinamou.

A native proprietor of a chocolate shop in Progreso had a female bird of this species which was so tame that it went about under the tables picking up crumbs from the floor. It could usually be heard uttering a peculiar low whistle, which was capable, however, of being heard at a considerable distance. Two eggs laid by this bird, which I secured from the owner, are green-blue (robin's-egg blue) in color, and have a hard, glossy surface. They are spheroidal in shape and measure respectively 60.6 mm. × 47.3 mm., and 60 mm. ×

48.4 mm. The identification of this specimen is certain, as a description was made at the time, and feathers from various parts of the bird were brought home for comparison. Just where the bird came from is not so certain, but as nearly as I could learn, it came from somewhere in the interior of Yucatan. It is unfortunate that this could not be determined more definitely, as the species appears not to have been previously reported from the peninsula, though it is known to occur to the southward in Guatemala and Honduras.

2. Creciscus ruber (Sclater & Salvin).

One specimen: ♂, Yucatan (Xbac?), 1901, G. F. Gaumer.

3. Larus philadelphia (Ord).

Bonaparte's Gull.

Large flocks on the Gulf at Progreso in the latter part of January.

4. Fregata aquila (Linné).

Man-o'-war Bird.

Common along the coast at Progreso during the latter part of January.

5. Speotyto cunicularia hypogaea (Bonaparte).

Burrowing Owl.

A single specimen, a female, was taken on the open ground of a henequen plantation at San Ignacio on February 9. Although well known from other parts of Mexico, this bird appears not to have been noted previously from Yucatan.

6. Ceryle alcyon (Linné).

Belted Kingfisher.

Common about the brackish Mangrove marshes back of Progreso during the latter part of January.

7. Momotus lessonii Lesson.

Lesson's Motmot.

One specimen, said to have been taken at Xbac in 1901, was given me by Dr. G. F. Gaumer.

8. Coccyzus minor (Gmelin).

Mangrove Cuckoo.

One specimen was given me by Dr. Gaumer.

9. Pyrocephalus rubineus mexicanus (Sclater).

Vermilion Flycatcher.

Two specimens were given me by Dr. Gaumer.

Rather common in the swampy land back of Progreso.

10. Heleodytes guttatus (Gould).

Yucatan Cactus Wren.

Three specimens:

a. ♀, Progreso, Feb. 4, 1904.

b, c. Xbac (?), 1901, G. F. Gaumer.

Although I obtained this bird at Progreso, whence it has been reported several times, I have no notes on its abundance or habits.

11. Mimus gilvus gracillis (Cabot).

Yucatan Mockingbird.

Maya neme, *tšī-kō*. "Native name 'Chico,' or 'Zenzotl.' The name of 'Zenzotl' is generally given in Mexico to all the species of Mocking-birds." — Boucard, Proc., Zool. Soc. Lond., 1883, p. 439.

One specimen, given me by Dr. Gaumer.

I found this bird common at Progreso, but did not see it at Chichen-Itza.

12. Cyanerpes cyaneus (Linné).

Blue Honey Creeper.

One specimen: Xbac (?), 1901, G. F. Gaumer.

Although reported from other States of Mexico and from other parts of Central America, there appears to be no previous record of this bird from Yucatan.

13. Volatinia jacarini splendens (Vieillot).

Blue-black Grassquit.

One specimen: [♂], Xbac (?), 1901, G. F. Gaumer.

REPTILIA, AMPHIBIA, AND PISCES.

By Thomas Barbour and Leon J. Cole.

Introduction.

The collections upon which this report is based are from the following sources: First, series obtained by Mr. Leon J. Cole; secondly, specimens from Mr. Edward H. Thompson, received at various times; thirdly, specimens in the Museum of Comparative Zoölogy from various sources other than those mentioned.

The literature on the lower vertebrates of Yucatan is not very extensive. Large collections have been made by Dr. G. F. Gaumer at various localities, and upon these specimens, for the most part, are based the Yucatan records of the Biologia Centrali-Americana. Ives, in the Proceedings of the Phila. Acad. for 1891, reported on the reptiles collected by Professor Heilprin's party; he described *Anolis acutirostris* as new; we record this species for the second time. Cope, in several papers, has also added

to our knowledge of the herpetology of Yucatan. Of the fishes less is known. The expedition of the *Albatross* to Cozumel Island resulted in a report on the fauna of that area; beyond this, however, little seems to have been published of the coast fishes. The fresh-water fishes are very few in number; that they are of great interest will be observed by examining the list which follows. Their distribution in the cenotes at Chichen-Itza is of especial interest. In the Sacred Cenote and in another cenote some three or four miles to the eastward and known as "Ikil" occur two entirely distinct species of catfishes, both of which, moreover, are new to science. Their habits are entirely distinct, as well as their specific morphological characters. This fact would appear to preclude the notion that these cenotes are connected by underground streams. On the other hand the "mojarra," *Heros urophthalmus*, occurs in both the Sacred and the great Cenote at Chichen-Itza, and is probably widely distributed throughout the peninsula. It is common in the brackish waters of the *cienaga* at Progreso. It has previously been reported only from Lake Peten, in Guatemala. This fish is used extensively for food and it is possible that the Indians have aided in its dissemination. One other species, *Heros affinis*, found in the *cienaga*, has been known previously only from Lake Peten.

Only a word is necessary to explain the apparent faunal relationships of the lower vertebrates of the Yucatan peninsula. Its fauna is, as would be expected, made up of typical species abundant in Mexico and in Central America. A few of the species are peculiar to the region. They, however, show no such special modifications as might have developed from peculiar local conditions, so that it seems reasonable to expect that with further investigation they may be found in the neighboring regions. In this way the lower vertebrates differ from the birds and mammals, which appear to have developed numerous local geographical races peculiar to Yucatan.

It is our pleasure to acknowledge our indebtedness to Dr. Leonhard Stejneger, Dr. B. W. Evermann, Mr. Samuel Garman, and Dr. Alex. G. Ruthven for advice and assistance in identification.

REPTILIA.

TESTUDINATA.

1. Cistudo mexicana (Gray).

Two examples from Chichen-Itza, Yucatan — an alcoholic specimen taken April 8, and a dried carapace.

2. Cinosternon leucostomum A. Dumeril.

One adult, dried, collected by Dr. G. F. Gaumer. Two young, in alcohol, from Chichen-Itza, taken by Mr. E. H. Thompson. Turtles, probably of this species, were reported several times as having been seen in the Sacred Cenote.

The specimens agree with the descriptions except that the first vertebral plate has convex sides instead of concave. The axillary and inguinal plates are in contact.

3. Thallasochelys cephalo (Schneider).

Skull found on the beach at Progreso. From the number of shells seen this species must be very common.

LACERTILIA.

4. Hemidactylus exsul, sp. nov.

Type. — No. 7039, Mus. Comp. Zoöl. Progreso, Yucatan, April 13, 1904. Leon J. Cole.

Snout about equal to distance between eye and ear openings: forehead concave: ear opening medium, ovoid, oblique. Body and limbs moderate. Digits rather dilated: two divided lamellae under the inner fingers; five under the second; six under the others. Three divided lamellae under the inner toes; six or seven under the others. Below these there are from one to three undivided lamellae beneath both fingers and toes. Granules on snout larger than those elsewhere. Among the granules of the back are fifteen rather irregular series of subtrihedral granules. These are about the same size as the ear opening, sometimes rather smaller. Rostral four-sided with a median cleft above, a little broader than high. Nostril between rostral, first labial, and three nasals. Mental large and subpentagonal: first pair of chin shields almost in contact behind the mental. Ventral scales small, subcycloid, slightly imbricate. Male with eight preanal pores in a curved series. Tail rather depressed, bearing tubercles on its base and rather large transverse plates below.

Color in alcohol: Grayish brown above, somewhat marbled with cinnamon, the darker spots occurring in three irregular series along the dorsal region and very irregularly on the head.

5. Thecadactylus rapicauda (Houttuyn).

One example from Chichen-Itza, Yucatan. Collected by Mr. E. H. Thompson.

6. Anolis aureolus Cope.

Six examples from Chichen-Itza. Identified by Dr. Stejneger.

7. Anolis ustus Cope.

Five examples from Chichen-Itza. Inclined to brownish below; one example shows a light vertebral stripe.

8. Anolis beckeri Boulenger.

One example from Chichen-Itza. Apparently typical, but in rather poor condition.

9. Anolis acutirostris Ives.

Two examples from Chichen-Itza.

10. Norops yucatanicus, sp. nov.

Types. — Three specimens, No. 7036, Mus. Comp. Zoöl. Chichen-Itza, Yucatan, Leon J. Cole.

Habit rather stout; head about once and a half as long as broad, a very little shorter than the tibia. Scales on head subequal and unicarinate. Occipital scale much smaller than ear opening; six labials to below the centre of the eye; ear opening oval and vertical; about one half the diameter of the eye. Gular appendage moderate, gular scales large and strongly keeled. Enlarged dorsal scales in twelve or thirteen rows. Lateral scales small and keeled. The adpressed hind limb reaches slightly beyond the tip of the snout; digits slightly dilated. Tail just about as long as head and body; covered with equal sharply keeled scales.

Color: (alcoholic specimen) uniform fawn color. In one specimen there is a dark dorsal band. This band is wider than the region of enlarged scales, and is prolonged half-way down the sides in points. The central area of this band is lighter than the lateral.

Two specimens are adult and one is young.

11. Basiliscus vittatus Wiegmann.

Five young examples and one female with eggs taken April 6, all from Chichen-Itza. There are many specimens in the Museum (M. C. Z. No. 6268) taken by Edw. H. Thompson at Merida.

12. Laemanctus alticoronatus Cope.

One example from Chichen-Itza.

Scales in 55 rows; Boulenger gives the rows of scales at from 45 to 51, and in *L. serratus* Cope from 57 to 61 rows. This specimen approaches *L. serratus* in the rather distinct vertebral serration. There are no white lines on the neck and thighs in this example; neither do white spots characteristically situated appear. This specimen seems ideally intermediate between the two species, but with only one specimen definite conclusions are unreasonable.

A description of the colors of the specimen while alive is added from the field notes: — "Under parts light yellowish green with brown markings; above this on sides a white stripe; then a reticulated region of darker green, and above this again a yellowish green stripe. Back with alternate blotches of green and black. Head bright pea green. Colors gradually fade towards tail, which becomes grayish brown."

13. Ctenosaura acanthura (Shaw).

A single example from Progreso, as well as a large series from Chichen-Itza.

Following Günther (Biol. Cent.-Amer., Rept., 1890, p. 56) we have placed these examples under this species. Ives (Proc. Phil. Acad. Nat. Sci., 1891, p. 459) records Yucatan examples under the name *C. cycluroides* Harlan.

14. Ctenosaura (Cachryx) defensor (Cope).

One example from Chichen-Itza.

According to Boulenger (Proc. Zool. Soc. London, 1886, p. 241) Cope's genus Cachryx is untenable because it has been shown to intergrade with Ctenosaura. Still its characters would seem sufficiently definitive to warrant the subgeneric use of the name.

15. Sceloporus chrysostictus Cope.

Three examples from Chichen-Itza, four from Progreso, and one from San Ignacio, taken on Feb. 9.

16. Sceloporus serrifer Cope.

One example taken March 15, at Chichen-Itza.

17. Sceloporus variabilis Wiegmann.

Eighteen examples from Progreso.

18. Cnemidophorus sexlineatus (Linné).

Sixteen examples from Chichen-Itza, nine from Progreso.

The specimens show very marked variability in size, marking, and squamation. We have the typical form as well as examples agreeing with descriptions of the varieties *mexicanus*, *angusticeps*, and *costatus* which Boulenger recognizes. For several specimens we would need to describe new subspecies were we to admit any to be different from the *forma typica*. It must be said, however, that among the large number which we have both taken and seen in Florida, no such variability ever occurs.

OPHIDIA.

19. Glauconia albifrons (Wagler).

One example from Chichen-Itza, collected in the Maya ruins by Mr. E. H. Thompson.

A second example has also been received, taken by Mr. E. H. Thompson at the same locality, date uncertain, but between 1890 and 1900.

20. Typhlops microstomus Cope.

One example, also from the Maya ruins near Chichen-Itza.

21. Leptognathus sanniola (Cope).

Three examples from Chichen-Itza. Two of these were taken by L. J. Cole, and one by Mr. E. H. Thompson.

These specimens show several peculiar variations from Cope's description. One example has three praeoculars on one side and two on the other. Two specimens have undivided anal scales, while the third specimen is incomplete and lacks the anal scale. These also have both more ventrals and subcaudals than seems typical. Cope's description calls for 156 + 55; while in ours the counts run $\frac{15}{162+77}$, $\frac{15}{152+72}$, and $\frac{15}{158+73}$. It is possible that the tail of Cope's specimen was broken.

In *L. dimidiata*, while the anal is undivided, there are no praeoculars and the ventrals count 185 – 195, subcaudals 98 – 126.

22. Tropidodipsas sartorii (Cope).

One example from Chichen-Itza. Agrees with var. A. of Boulenger, Cat. Snakes British Museum, **2**, p. 297. Scales $\frac{17}{191+63}$; there is one more ventral than the maximum number cited by Boulenger.

23. Leptodeira yucatanensis (Cope).

One example taken at Chichen-Itza by Mr. E. H. Thompson.

The cross bands descend to the ventrals, the lateral spots are general, the lower surfaces immaculate. Sc. $\frac{21}{190+65}$.

The stomach of this specimen, about 20 inches long, contained an example of *Ctenosaura acanthura* about 7 inches long.

Another specimen has been received, taken also at Chichen-Itza by E. H. Thompson, 189–.

24. Himantodes gemmistratus Cope.

Dipsas gracillima Günther. Biol. Cent.-Amer., Rept., 1895, p. 177, pl. 56, fig. B.

One example from Progreso, Yucatan. Sc. $\frac{17}{225-153}$; forty-four dark brown markings on body; thirty-one on tail.

An example from Chichen-Itza taken by Mr. E. H. Thompson, 189–, has recently been received.

25. Thamnophis saurita proxima (Say).

Three examples from La Cienaga, Progreso. Taken by L. J. Cole. These were sent to Mr. Alex. G. Ruthven of Ann Arbor, Michigan, who has very kindly returned the following remarks:—

"The three specimens sent me . . . belong to the *saurita* group, of Garter Snakes, as is shown by the position of the lateral stripe on the 3d and 4th

rows of dorsal scales, and the very slender body and long tail. As is to be expected, these specimens are most closely related to the nearest geographical representative of the group (*proxima*), and differ from this form but little. The proportionate length of the tail falls well within the limits of variation in *proxima*, as do also the number of caudal plates. The number of dorsal rows of scales (19–17) is exactly the same as in *proxima* specimens. In one of the specimens there are 7 supralabials on one side, which may or may not indicate a tendency toward a reduction in this region, but the number of ventral plates (150 in the only specimen in which they can be counted) is decidedly less than is normal in *proxima*, which has a range of variation from about 164 to 174. Since but one specimen has been examined this small number might be considered abnormal were it not for the fact that Orizaba specimens and Cope's type of *rutiloris*, both of which belong to this group, also possess a smaller number of ventral plates than is normally the case in *proxima* specimens.

"The general type of color is the same as in *proxima*. The ground color above is dark greenish olive, the belly light bluish. The lateral stripes are narrow and are situated on the 3d and 4th rows of dorsal scales. The dorsal stripe is rather inconspicuous. The labials are uniformly white (possibly red in life). There are the usual light bars on the preoculars in front of the eye, and on the lower postoculars. There are no spots on the end of the gastrosteges, on the dorsal scales, or labials. Dorsal scales 19–17 in all specimens; supralabials 8; 8; R. 7, L. 8: infralabials 10; R. 10, L. 11; 10: oculars 1–3; L. 2–3, R. 1–3; 1–3: temporals 1–2 in all: urosteges'88; 91; 81: gastrosteges 150; ?; ?."

26. Coluber triaspis Cope.

One specimen, young, from Chichen-Itza.

Concerning this specimen, Dr. Stejneger very kindly writes under date of Oct. 9, 1905:

"The snake is *Coluber triaspis*. I have compared it with the types of *C. flavirufus*, *mutabilis*, and *triaspis*. It is not the first mentioned; it agrees exactly with the second, which is probably a synonym of the third. *C. triaspis* type seems to be an abnormal specimen with 3 loreals and 4 first temporals, otherwise = *mutabilis*."

27. Herpetodryas carinatus (Linné).

One specimen lately received from Mr. E. H. Thompson. Taken at Chichen-Itza, 189–.

This specimen is interesting in that the median five series of scales are keeled; the median three distinctly, the outer pair considerably less so.

28. Coronella micropholis (Cope).

One example, adult taken at Chichen-Itza on April 6, 1904, by L. J. Cole. This is a large example and represents var. B. of Boulenger's Cat. Snakes Brit. Mus., **2**, p. 203, 204. Sc. $\frac{21}{212 + 53.}$

A second example, young and imperfect, was found in the same locality on March 6. This represents var. E., Boulenger, *loc. cit.*, **3**, p. 405.

A third, also young, has been received from Mr. E. H. Thompson. Taken at the same locality, during the years 1890–1900.

29. Conophis lineatus concolor (Cope).

One example from Chichen-Itza, taken April 6. Sc. $\frac{19}{166 + 72}$; this specimen seems to fall under *C. lineatus* var. B., Boulenger, *loc. cit.*, 3, p. 122, 123.

30. Ficimia olivacea publia (Cope).

One example from Chichen-Itza.

Sc. $\frac{17}{145 + 37}$; there are twenty-six bars on the body and nine on the tail. The internasals are perfectly distinct.

31. Geophis multitorques yucatanicus, subsp. nov.

Type. — One specimen, No. 7037, Mus. Comp. Zoöl. Chichen-Itza, Yucatan, March 6, 1904, Leon J. Cole.

This form differs from *G. multitorques* (Cope) in having seven upper labials, two postoculars, a divided anal, and in being uniform plum-brown in color. Each scale has a darker dot at its apex. Sc. $\frac{17}{174 + 31}$.

32. Elaps fulvius (Linné).

Two examples from Chichen-Itza.

One example with sixteen black annuli on the body; anal divided, and sc. $\frac{15}{217 + 43}$.

The other example has only thirteen annuli of black on the body, the anal is entire, and sc. $\frac{15}{221 + 41}$.

These seem to fall under var. B., Boulenger, *loc. cit.*, **3**, p. 424.

33. Crotalus terrificus (Laurenti).

Three examples from Chichen-Itza; one young, two half-grown.

These fall under var. B. of Boulenger, *loc. cit.*, **3**, p. 575. The stripes on the neck are well marked in all three examples.

AMPHIBIA.

1. Rana virescens areolata (Baird & Girard).

Two specimens taken from brackish water in La Cienaga near Progreso, Jan. 28–Feb. 10. Four from Chichen-Itza taken during March.

2. Bufo valliceps Wiegmann.

Four specimens from Chichen-Itza taken during April.

"This toad trills at a high pitch." Ives reports this toad from Yucatan (Proc. Phil. Ac. Nat. Sci., 1892, 1891, p. 461).

3. Bufo marinus (Linné).

Seven examples from Chichen-Itza, Yucatan.

Both *B. marinus* and *B. valliceps* were common in the cenotes, and were often found about watering troughs at the house as well. They were breeding in February, and on Feb. 19 eggs were observed, though it is uncertain to which species they belonged. By March 18 the tadpoles had reached a length of 2 cm. or so in the Sacred Cenote, and had become scattered about instead of swimming in dense schools as before. Mr. Thompson says that when the toads come to the cenotes to breed they plunge directly off from the top of the vertical walls to the water 65 feet below. The old toads after breeding and the young toads also appear to get out by working their way laboriously up the walls, taking advantage of the small irregularities.

4. Hyla phlebodes Stejneger.

Proc. U. S. Nat. Mus., 1906, **30**, pp. 817, 818.

Two examples from Chichen-Itza, compared with the type by Dr. Stejneger.

5. Hyla baudinii Dumeril & Bibron.

One example taken March 22, at Chichen-Itza, Yucatan.

"Call of this species a resonant *kwa, kwa, kwa* (*a* as in father). Most frequently heard in a tall cocoanut-palm. At night they come down to among the challote vines which grow about the water tank. The note is pitched low, but is of a far-reaching quality. Usually uttered three or four times in succession, at intervals of perhaps five minutes."

6. Triprion petasatus (Cope).

One specimen taken at Chichen-Itza, March 28.

"Note an unmusical, rather drawn-out *quarr — quarr — quarr.* Not guttural, but with a rasping quality. Life colors as follows: Top of head fuscous, with silvery greenish gray dots; back silvery gray, with dark fuscous blotches and smaller spots; sides with yellowish green suffusion; arms and legs brown, with yellowish blotches on upper arms and legs; silvery gray on lower arms and legs. Under sides whitish. The gray has a decided greenish tinge, which became more marked in a short time while the creature was held in the hand. This frog was not heard during the drier part of the season (February and most of March), but was heard quite frequently during the last part of March, when there was more rain."

7. Spelerpes yucatanus Peters.

S. yucatanicus Boulenger. Cat. Batr. Grad. Brit. Mus., 1862, p. 72.

One specimen from Chichen-Itza, taken, together with a single egg, in the damp earth near a watering trough on March 7.

PISCES.

1. Scoliodon terrae-novae (Richardson).

One specimen from Progreso.

2. Sphyrna tiburo (Linné).

One specimen from Progreso.

3. Urolophus jamaicensis (Cuvier).

One specimen from Progreso.

4. Dasybatis hastata (DeKay).

One specimen from Progreso.
This species seems to be considered a favorite food fish.

5. Felichthys marinus (Mitchill).

Two specimens from the Gulf of Mexico at Progreso.

6. Rhamdia depressa, sp. nov.

Plate 1.

Types. — Eleven examples, No. 29072, Mus. Comp. Zoöl. Ikil Cenote, near Chichen-Itza, Yucatan, Leon J. Cole.

Head $4\frac{2}{5}$; D. 1, 6; A. 10. Body rather slender, more stout anteriorly than posteriorly; head rather large, flat, narrowed forward. Eye rather high up, small, its diameter $6\frac{2}{3}$ in head. Teeth in bands. The maxillary barbel reaches the base of the anal fin; in some specimens it is rather shorter, but in none longer. The mental barbel reaches about half-way to base of pectoral, and the postmental considerably beyond the base of the pectoral fin. Origin of spinous dorsal fin rather less than half way from origin of ventral fins to gill opening. Length of base of adipose dorsal fin $3\frac{1}{3}$ in total length. The caudal fin is forked; its lobes are rounded but somewhat narrow. Ventral fins inserted below the posterior limit of the base of the spinous dorsal fin.

Color uniform dull brown. The largest specimen of this series is about a foot long.

Field notes. Ikil Cenote is about three miles east of Chichen-Itza. It is about 100 ft. in diameter, but on the east and south sides a projecting ledge covers it for nearly a third of the distance. A sounding through a well in this overhanging part gave 65 ft. to water, and 95 ft. depth of water. These silu-

roids were numerous and could be seen swimming slowly about near the surface. They took bait readily; even if a stone was thrown in they swam rapidly to the spot.

7. Rhamdia sacrificii, sp. nov.

Plate 2.

Types. — Two examples, No. 29073, Mus. Comp. Zoöl. Sacrificial Cenote, near Chichen-Itza, Yucatan, Leon J. Cole.

Head $4\frac{3}{4}$; D. 1, 6; A. 10. Body stout its entire length; head large, flat, little narrowed forward. Eye very high up, small, its diameter $7\frac{1}{2}$ in head. Teeth in bands. The maxillary barbel reaches a little beyond the base of the ventral fins. The mental barbel reaches about three fifths of the distance to the pectoral, and the postmental a little beyond the base of the pectoral. Origin of spinous dorsal a little posterior to a vertical line from posterior part of base of pectoral fin. Length of base of adipose dorsal fin $2\frac{5}{6}$ in total length. The caudal fin is forked; its lobes are bluntly rounded, almost truncate. Ventral fins inserted a little caudad of the posterior limit of the spinous dorsal fin.

Color uniform dark slaty gray. The larger specimen is slightly more than one foot in length.

Unlike the preceding species, *R. sacrificii* appears to be a bottom form, and was never seen at the surface. It also took the bait much less readily.

8. Elops saurus Linné.

Two specimens from the Gulf of Mexico at Progreso.

9. Sardinella sardina (Poey).

Seventeen examples from the Gulf of Mexico at Progreso.

10. Stolephorus brownii (Gmelin).

Thirteen specimens from the Gulf of Mexico at Progreso.

11. Synodus foetens (Linné).

Two examples from the Gulf of Mexico.

12. Fundulus grandis Baird & Girard.

Eleven examples from La Cienaga near Progreso.

The largest size mentioned by Garman (Cyprinodonts, p. 97) for this species is six inches. Among this series, however, are several nearly ten inches long. The upper surface of the head is extremely flat: the eye, when seen in side view, has its upper edge elevated above the contour line of the head. It is rather more elevated than is shown in Girard's figure (Mex. Boundary Surv., **2**, p. 69, pl. 36).

13. Cyprinodon eximius Girard.

Fifty-one specimens from La Cienaga near Progreso, Yucatan.

14. Jordanella floridae Goode & Bean.

Twenty-five specimens from La Cienaga near Progreso.

15 Gambusia gracilis Heckel.

Eleven specimens from La Cienaga near Progreso.

16. Belonesox belizanus Kner.

Eight specimens from La Cienaga near Progreso.

17. Mollienisia latipinna Le Sueur.

Sixty-one examples (♂'s, ♀'s, and young) from La Cienaga near Progreso. Many examples have well-defined bands through the eyes passing upwards and forwards.

18. Tylosurus marinus (Walbaum).

Five examples from La Cienaga near Progreso.

19. Hyporhamphus unifasciatus (Ranzani).

Three specimens from the Gulf of Mexico near Progreso.

20. Mugil curema Cuvier & Valenciennes.

One specimen from the Gulf of Mexico near Progreso.

21. Mugil trichodon Poey.

One specimen from La Cienaga near Progreso.

22. Scomberomorus regalis (Bloch).

One specimen from the Gulf of Mexico at Progreso.

23. Caranx hippos (Linné).

One specimen from La Cienaga near Progreso.

24. Selene vomer (Linné).

One young specimen from the Gulf of Mexico at Progreso.

25. Epinephelus morio (Cuvier & Valenciennes).

Three specimens from the Gulf of Mexico at Progreso.

26 Diplectrum formosum (Linné).

Three specimens from the Gulf of Mexico at Progreso.

27. Neomaenis griseus (Linné).

One specimen from the Gulf of Mexico at Progreso.

28. Neomaenis synagris (Linnè).

Two specimens from the Gulf of Mexico at Progreso.

29. Haemulon plumieri (Lacépède).

Two specimens from the Gulf of Mexico at Progreso.

30. Orthopristis chrysopterus (Linné).

Five specimens from the Gulf of Mexico at Progreso.

31. Cynoscion nebulosus (Cuvier & Valenciennes).

One specimen from the Gulf of Mexico at Progreso.
"A much prized food fish."

32. Sagenichthys ancylodon (Bloch & Schneider).

One specimen from the Gulf of Mexico at Progreso.

33. Corvula sanctae luciae Jordan.

One specimen from La Cienaga near Progreso.

34. Bairdiella chrysura (Lacépède).

One specimen from the Gulf of Mexico at Progreso.

35. Menticirrhus americanus (Linné).

One specimen about one foot long, and five somewhat smaller from the Gulf of Mexico at Progreso.

36. Heros affinis Günther.

One specimen from Progreso, taken in La Cienaga.

This specimen does not agree exactly as to color markings and it has 15 dorsal spines instead of the usual 16. Previously known only from Lake Peten, Guatemala.

37. Heros urophthalmus Günther.

Many specimens from La Cienaga at Progreso and also from the Great and Sacred Cenotes at Chichen-Itza.

They range in size from one to about ten inches long. "At Progreso this fish is much used for food. It was common in the cenotes at Chichen-Itza, but the specimens taken did not appear to be as large as those taken near the coast. Their coloration was, however, somewhat brighter. Specimens from the Great Cenote have been introduced into the water troughs at the hacienda for three or four years. Here they were living very well. It was noted that

in the tanks containing these fishes mosquito larvae were entirely absent, whereas in the tanks without fishes larvae were exceedingly abundant. The fact that these fishes live so well in small bodies of water offers the suggestion that they may prove of practical value in aiding to subdue the mosquito pest in Yucatan."

This species has apparently been known thus far only from three specimens taken in Lake Peten by Salvin and Godman.

38. Balistes carolinensis Gmelin.

One specimen from the Gulf of Mexico at Progreso.

39. Lagocephalus pachycephalus (Ranzani).

Three specimens from the Gulf of Mexico at Progreso.

40. Lagocephalus laevigatus (Linné).

Two specimens from the Gulf of Mexico at Progreso.

41. Opsanus tau (Linné).

One specimen from Gulf of Mexico at Progreso.

42. Opsanus pardus (Goode & Bean).

Three specimens from Progreso, Gulf of Mexico.

43. Emblemaria atlantica Jordan & Evermann.

One specimen from La Cienaga near Progreso.

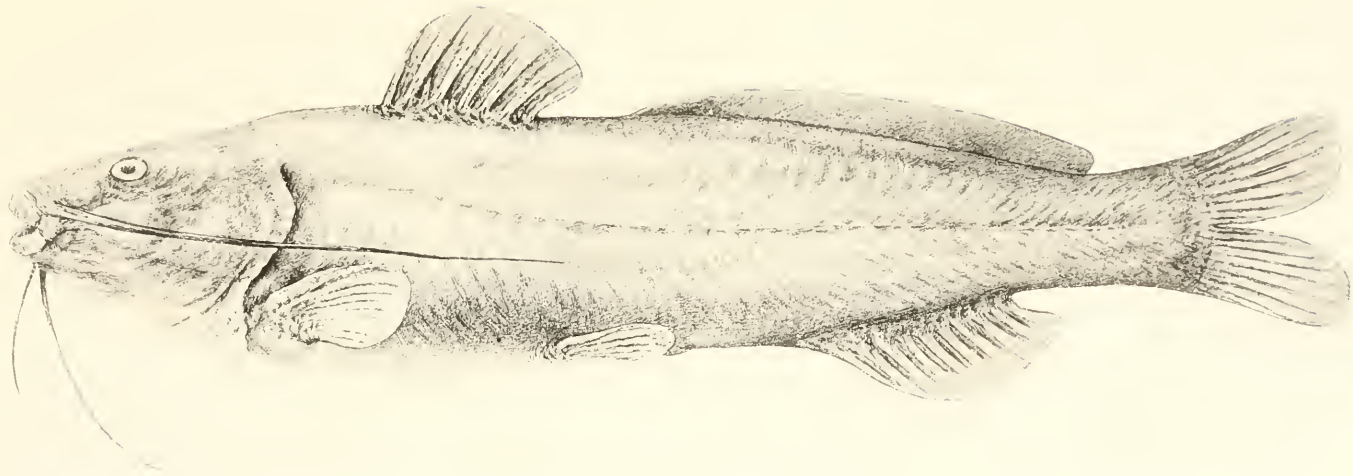
44. Echeneis naucrateoides Zuiew.

Two specimens from the Gulf of Mexico at Progreso.

One specimen with but 18 laminae in the disc, the other has 20. Jordan and Evermann (Fishes of North and Middle America, p. 2270) give 20 or 21 as the characteristic specific number.

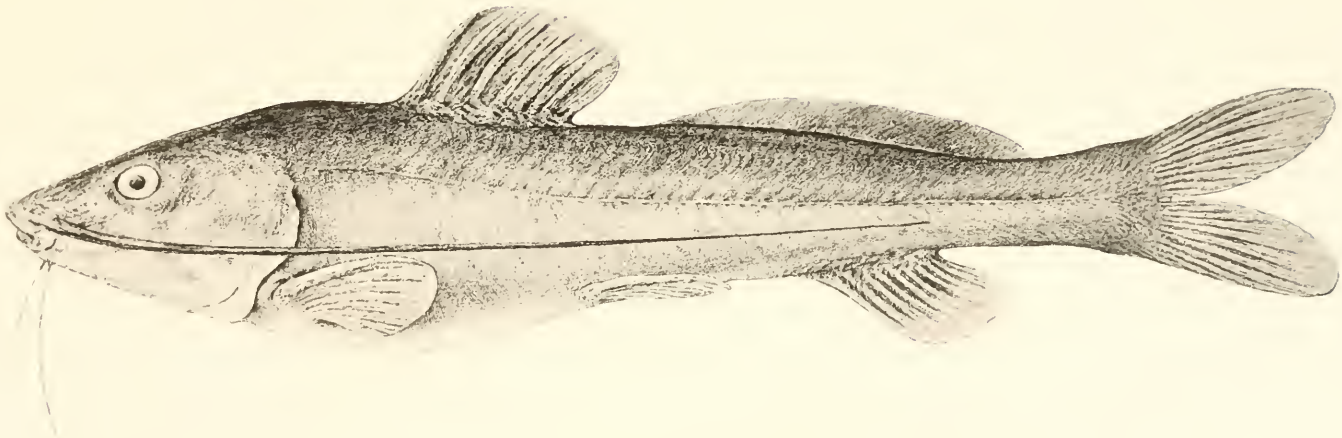
45. Ogcocephalus vespertilio (Linné).

One young specimen from the Gulf of Mexico at Progreso.



C. H. L. GEBFERT, DEL. HELIOTYPE CO., BOSTON.

RHAMDIA SACRIFICII.



C. H. L. GEBFERT, DEL. HELIOTYPE CO., BOSTON.

RHAMDIA DEPRESSA.

No. 6. — *Reports on the Scientific Results of the Expedition to the Eastern Tropical Pacific, in charge of* Alexander Agassiz, *by the U. S. Fish Commission Steamer "Albatross," from October, 1904, to March, 1905,* Lieut. Commander L. M. Garrett, U. S. N., *commanding.*

IX.

New Species of Dinoflagellates. By Charles Atwood Kofoid.

The pelagic collections of the Expedition made with the fine silk nets, especially those made at the depth of 300 fms. and brought to the surface in the open net, have contained a considerable number of species of Dinoflagellates which are as yet undescribed. Pending the publication of the final report with full illustrations, the following brief descriptions, accompanied by simple figures, are published of the new forms for which the plates are in preparation.

No attempt is made in these descriptions to discuss morphological or systematic problems, nor to indicate or discuss the distribution of the forms described. Nor is any list of the species found given herewith, since practically all known species of this group have occurred in the collections.

Noteworthy among the forms here described is the considerable number of new species of *Amphisolenia*, *Heterodinium*, *Ceratium*, and *Oxytoxum*. There is also included a new genus, *Acanthodinium*, which throws some light on the relationships of the problematical organism *Cladopyxis*, linking it with little doubt near to the Ceratiidae in the system. A unique new genus, *Centrodinium*, is represented by three species, and *Murrayella*, related to *Oxytoxum*, including four species, is also new. The plates of the obscure and puzzling genus *Protoceratium* are defined for the first time, and three species are added to the highly phosphorescent genus *Pyrocystis*. The discovery of a new representative of *Ptychodiscus*, a genus not reported since its description by Stein in 1883, is recorded.

In all three new genera, eighty-four new species, nine new "forms" are described. Unless otherwise stated they are all from collections

made by nets of No. 12 or 20 silk towed at depths of 300 fms., but open during both the descent and ascent. The types will be deposited in the United States National Museum, and co-types in the Museum of Comparative Zoölogy of Harvard College.

The species described are distributed as follows in the system: —

DINOFLAGELLIDIA.

ADINIDA.

Prorocentridae.

1. Prorocentrum curvatum.

DINIFERIDA.

Gymnodinina.

Pyrocystidae.

2. Pyrocystis acuta.
3. Pyrocystis fusiformis forma biconica.
4. Pyrocystis semicircularis (Schröder.)
5. Pyrocystis robusta.

Gymnodinidae.

6. Pouchetia panamensis.

Peridinina.

Ptychodiscidae.

7. Ptychodiscus carinatus.

Ceratiidae.

CERATIINAE.

8. Steiniella inflata.
9. Protoceratium areolatum.
10. Ceratium axiale.
11. Ceratium bigelowi.
12. Ceratium claviger.
13. Ceratium ehrenbergi.
14. Ceratium pacificum Schröeder.
15. Ceratium dilatata (Karsten).
16. Ceratium lanceolatum.
17. Ceratium pennatum.
18. Ceratium pennatum forma propria.
19. Ceratium pennatum f. inflata.
20. Ceratium pennatum f. falcata.
21. Ceratium schroeteri Schröder.
22. Ceratium scapiforme.
23. Ceratium tricarinatum.
24. Peridinium fatulipes.
25. Peridinium grande.
26. Peridinium latissimum.
27. Peridinium longispinum.
28. Peridinium murrayi.
29. Peridinium tenuissimum.
30. Heterodinium agassizi.
31. Heterodinium calvum.
32. Heterodinium curvatum.
33. Heterodinium expansum.

34. Heterodinium fenestratum.
35. Heterodinium fides.
36. Heterodinium gesticulatum.
37. Heterodinium gesticulatum forma typica.
38. Heterodinium gesticulatum f. extrema.
39. Heterodinium gesticulatum f. mediocris.
40. Heterodinium gesticulatum f. deformata.
41. Heterodinium globosum.
42. Heterodinium hindmarchi f. maculata.
43. Heterodinium laticinctum.
44. Heterodinium longum.
45. Heterodinium obesum.
46. Heterodinium praetextum.
47. Heterodinium superbum.
48. Centrodinium complanatum (Cleve).
49. Centrodinium deflexum.
50. Centrodinium elongatum.

PODOLAMPINAE.

51. Podolampas reticulata.

OXYTOXINAE.

52. Oxytoxum challengeroides.
53. Oxytoxum compressum.
54. Oxytoxum cristatum.
55. Oxytoxum curvicaudatum.
56. Oxytoxum gigas.
57. Oxytoxum subulatum.
58. Oxytoxum turbo.
59. Murrayella globosa.
60. Murrayella spinosa.
61. Murrayella punctata (Cleve).
62. Murrayella rotundata.

Cladopyxidae.

63. Acanthodinium caryophyllum.
64. Acanthodinium spinosum.

Dinophysidae.

65. Phalacroma lenticula.
66. Phalacroma reticulata.
67. Phalacroma striata.
68. Phalacroma ultima.
69. Dinophysis triacantha.
70. Amphisolenia asymmetrica.
71. Amphisolenia bispinosa.
72. Amphisolenia brevicauda.
73. Amphisolenia clavipes.
74. Amphisolenia curvata.
75. Amphisolenia dolichocephalica.
76. Amphisolenia extensa.
77. Amphisolenia laticincta.
78. Amphisolenia lemmermanni.
79. Amphisolenia palaeotheroides.
80. Amphisolenia projecta.
81. Amphisolenia quadrispina.
82. Amphisolenia quinquecauda.
83. Amphisolenia rectangulata.
84. Amphisolenia schroederi.
85. Triposolenia longicornis.
86. Triposolenia fatula.
87. Triposolenia ambulatrix.
88. Histioneis carinata.
89. Histioneis garretti.
90. Histioneis josephinae.
91. Histioneis longicollis.
92. Histioneis navicula.
93. Histioneis paulseni.
94. Histioneis pulchra.
95. Histioneis reticulata.
96. Ornithocercus carolinae.
97. Ornithocercus heteroporus.
98. Ornithocercus serratus.

Amphilothidae.

99. Amphilothus quincuncialis.

Prorocentrum curvatum, sp. nov.

Plate 1, Figs. 1, 2.

A small species with lanceolate curved body.

Body elongated, its length (dorso-ventral axis) 3 times the transdiameter and 5.5 times the antero-posterior one. Ventral end widest, truncate, bearing a short median flagellar collar which is anterior to the level of the suture. The body has nearly straight lateral margins for 0.5 of the length, then tapers to a blunt point. Seen from the side the body is curved posteriorly, the more distally, till the dorsal apex is almost at right angles to the ventral axis. The posterior valve is concave, and nearly flat, the anterior is convex both dorso-ventrally and transversely.

The thecal wall bears 6–7 longitudinal rows of close set pores on each valve.

Chromatophores small, irregular, dark yellow.

Length (dorso-ventral axis), 65 μ; transdiameter, 22 μ.

Station, 4720.

Pyrocystis acuta, sp. nov.

Plate 1, Fig. 4.

A large species with slender, straight, or slightly concave, cylindrical body swollen at the centre and abruptly pointed at the tips. The length is 13–21 times the diameter of the swollen midregion. The shaft beyond the midbody is 0.35–0.6 of the greatest diameter. The taper to the acute point is confined within one transdiameter of the end. The ends and the midbody differentiate the species clearly from *P. lanceolata*.

Length, 675–1400 μ; transdiameter, 45–95 μ.

Stations, 4728, 4732, 4740.

Pyrocystis fusiformis f. biconica, f. nov.

Plate 1, Fig. 3.

A small biconical form with broadly rounded apices and midregion. Apparently intermediate in form between *P. noctiluca* and *P. fusiformis* but not plainly intergrading with either. The length is 1.4–2.75 times the diameter. Differs from *P. fusiformis* in its relatively greater girth and in its straight rather than convex sides.

Length, 160–380 μ; transdiameter, 60–215 μ.

Stations, 4728, 4732, 4740.

Pyrocystis semicircularis (Schroeder).[1]

Plate 1, Fig. 6.

A medium-sized species with small ellipsoidal midbody and long slender cylindrical tapering incurved horns. Often yoked in pairs, as in *P. hamulus*.

[1] Schröder, B. Beiträge zur Kenntnis des Phytoplanktons warmer Meere. Viert. Nat. Ges. Zurich, **51**, p. 319–377, 1906. Received while this paper was in press.

Outline of the conplet and of long-horned single individuals nearly circular or elliptical. Midbody more convex on inner than on outer face of the arc, its length 1.7–2 times its transdiameter. The horns are tapering, sharp pointed, their distal ends sharply incurved, or with sigmoid flexure. Their length 4.5–10 transdiameters. The two horns are unequal in length, one being 1.1 times the length of the other. The long and the short horns are joined in the couplets.

Differs from *P. hamulus* in the larger size, less abrupt flexure of the arms, in the absence of the sharp double flexure at the midbody, and in the fact that the arms are more nearly equal in length.

Long axis of ellipse, of single or yoked individuals, 315–580 μ; transdiameter of midbody, 40–62 μ.

Stations, 4691, 4728, 4740.

Pyrocystis robusta, sp. nov.

Plate 1, Fig. 5.

A small species of robust habit, deeply crescentic. Differs from *P. lunula* in its greater curvature, stouter body, and absence of central expansion.

Body fusiform but bent into a deep crescent whose tips nearly meet or even overlap. The convex margin is circular in outline, and the gap between the tips is less than 0.25 of the circumference. The diameter of the spherical or oval area enclosed by the crescent is 0.5, rarely 0.3–0.4, of the diameter of the larger circle. Greatest width at the middle of the body, tapering gradually to the tips. Width, 0.14–0.22 of the axial length.

Diameter of outer circle, 77–215 μ; width of body at middle, 26–90 μ.

Stations, 4728, 4740.

Pouchetia panamensis, sp. nov.

Plate 1, Fig. 7.

A minute species with symmetrical ellipsoidal body and minute lens and melanosome.

Body elongated, ellipsoidal, its length 1.5 times its transdiameter. Epicone about equal to hypocone. Apex broadly rounded, antapex also rounded, flattened ventrally. Girdle very oblique, transverse furrow very wide, 0.2 of a transdiameter in width, deeply impressed, forming a descending right spiral, displaced 6.5 times its width, and with an overhang of 0.25 of the circumference. Longitudinal furrow, 0.25 of the width of the transverse furrow extending from near the apex to the antapex, where it widens and spreads in two lateral bifurcations, twisted 0.30 of the circumference around the body. Transverse flagellum arises at anterior junction and longitudinal at posterior junction of furrows. Ellipsoidal nucleus in hypocone, stout crescentic melanosome with minute spheroidal lens.

Length, 34 μ; transdiameter, 21 μ.

Anchorage at Panama.

Ptychodiscus carinatus, sp. nov.

Plate 1, Figs. 8, 9.

A small disk-shaped species with concave anterior and posterior faces, wide furrow and ventro-posterior keel with the longitudinal furrow on its edge.

Body low, flat, disk-shaped, its length, including the keel, 0.33 of the transdiameter, which equals the dorso-ventral diameter. Excluding the keel the length is less than 0.25 of the diameter. The epitheca is a circular disk, notched ventrally, with concave anterior face, and broadly rounded edges which pass over into the large transverse furrow.

The hypotheca is also circular, disk-shaped, with somewhat concave posterior face. It is smaller than the epitheca, its diameter being about 0.9 of that of the epitheca. The hypotheca bears a thin ventral keel passing in a radial position from the centre of the posterior face to the flagellar pore. Its height is greatest about one third of the length from the centre, and is about 0.16 of the diameter. It bears the linear longitudinal furrow on its ventro-posterior edge.

The girdle is very wide with rounded edges, is deeper laterally than dorsally, is wider proximally than distally, so that a slight descending right spiral with little displacement is present. The longitudinal furrow lies in the ventral depression of the keel, is elliptical in outline on the epitheca, where it extends 0.6 of the distance to the centre.

Surface without sutures, pores, or reticulations. Figure sketched from life. Material in formalin is somewhat less depressed.

Length, 28 μ; transdiameter, 90 μ.

Station, 4722.

Steiniella inflata, sp. nov.

Plate 2, Fig. 15.

A large hyaline species with robust body and with anterior end of longitudinal furrow bifurcated, very narrow girdle, and broad intercalary bands along sutures.

The body irregular and asymmetrical, its length 1.1 times the dorso-ventral and 1.2 times the transdiameter, its epitheca conical, deflected to the left, and rotund ventrally, the right side more rotund than the left. Its altitude 0.6 of the transdiameter. Apical pore in right margin of longitudinal furrow which passes beyond the apex.

Hypotheca larger than epitheca, its total altitude 0.7 of the total length and 0.8 of the transdiameter. Antapex asymmetrical, broadly rounded, longer upon the left side, with broad ventral excavation.

Girdle narrow, ribbed, slightly impressed, with prominent margins, forming a descending right spiral with displacement five times its own width. Both proximal and distal ends curved posteriorly, the latter more than the former. Longitudinal furrow passing nearly one fourth of the distance beyond the apex

toward the girdle, bifurcated near the apical pore, passing posteriorly 0.6 of the distance to the antapex.

Sutures marked by broad structureless intercalary bands. Epitheca with 5 precingulars, and 1 apical which is deeply cleft by the longitudinal furrow but appears to lack the dorsal median suture necessary to complete the division into two plates. A minute accessory plate in the precingular series at the left of the longitudinal furrow. Hypotheca with 5 postcingulars, 1 antapical, and an accessory near the longitudinal furrow. The right ventral precingular and left ventral postcingular are small plates.

Plates reticulate with characteristic reticulations similar to those of *S. fragilis*, with quite regular arrangement in places. Scattered nodal pores in the mesh and eccentric pores in each reticulation.

Length, 165 μ; transdiameter, 115 μ.

Station, 4728.

PROTOCERATIUM (Bergh) Kofoid.

The thecal plates of this genus have not hitherto been determined, as the known species have lacked suture ridges and the density of the contents has interfered with the determination of the thecal structure. The following species has the plates clearly defined, and the definition of the genus may be accordingly emended.

Thecal wall definitely divided into plates, epitheca with one hexagonal apical plate and no apical pore, six nearly equal precingulars, the midventral one adjacent to, or containing the anterior end of the longitudinal furrow; hypotheca with six nearly equal postcingulars, the midventral one smaller and forming the posterior part of the longitudinal furrow plate, and one large antapical.

Protoceratium areolatum, sp. nov.

Plate 12, Fig. 71.

A minute species of ellipsoidal form. Thecal wall coarsely areolate, sutures marked by heavy ribs.

Body almost a perfect ellipsoid, the length 1.25 times the diameter *in* the furrow, and nearly equalling the diameter *on* the lists of the girdle. Epitheca less than the hypotheca by the width of the girdle, a low dome, abruptly flaring into the wide list, its altitude 0.33 of the diameter on the lists. Midventral plate slightly flattened, left side slightly wider than the right.

Hypotheca hemispherical, midventral plate somewhat excavated.

The girdle is wide, with wide, membranous, ribbed lists, furrow scarcely impressed, forming a descending right spiral with displacement equalling its width. Flagellar pore at proximal end of posterior list. Longitudinal furrow confined to girdle and hypotheca, running back to antapical plate on the ventral postcingular.

Plates normal, suture lines marked by ridges somewhat heavier than those

about the areoles. Suture lines with fins. Spines at the angles. Wall areolate with very large subequal polygons, 13–15 on the circumference at the girdle, 4–6 in each of the pre- and postcingular plates. No pores.

Length, 29 μ ; diameter, 22 μ.

Station, 4699.

Ceratium axiale, sp. nov.

Plate 4, Fig. 26.

A medium-sized species of the *C. tripos* group, with apical horn bent to the right, narrowly rounded shoulders and antapicals flexed close to the midbody and subparallel to the apical distally.

The midbody is rotund. The postmargin is a slightly asymmetrical arc whose radius equals the transdiameter. The antapicals are thus bent anteriorly very close to the midbody. The right horn is nearer to the midbody than the left, and bends laterally with more or less concavity on the outer face. It is longer than the left antapical, which is convex laterally and more removed from both the midbody and the apical horn. The distance between the antapicals distally is usually less than a transdiameter, while at the level of the girdle it is 1.25–1.75 transdiameters. The right antapical is sometimes bent beyond the apical, crossing it dorsally.

Length, 175–285 μ ; transdiameter, 45–60 μ; left antapical, 110–160 μ ; right antapical, 115–200 μ.

Stations, 4638–4732.

Ceratium bigelowi, sp. nov.

Plate 3, Fig. 22.

An elongated species of the *C. furca* group, with inflated midbody, whose greatest transdiameter is over twice that at the girdle, long curved apical, and left antapical whose end is curved dorsally and to the left. Apical horn slightly curved to the left. The height of the midbody above the girdle to the base of the apical horn is about four transdiameters at the girdle. Antapex of left horn spinulate. Ventral plate small, oblique, ellipsoidal. Right antapical very short, its end scarcely a transdiameter from the girdle. The hypotheca is relatively small, and the inflated part of the epitheca is in the region of the base of the apical plates.

Length, 900–1030 μ; transdiameter at girdle, 40 μ; greatest transdiameter of epitheca, 80–100 μ.

Stations, 4728–4730.

Ceratium claviger, sp. nov.

Plate 4, Fig. 27.

A small species related to *C. ranipes* with rounded shoulders and club-shaped, rarely bifurcated ends of the antapicals which are subparallel to the apical.

Apical horn straight, midbody as in *C. ranipes*. Postindentation slight, if

any, shoulders broadly rounded, the major curvature within about one transdiameter from the sides of the midbody at the level of the girdle. Antapicals often flexed outwardly distally. Their antapices swollen to 0.2–0.5 transdiameters in width or partially bifurcate in two subequal lobes, crowded with chromatophores and amyloid bodies. Thecal surface rugose, shoulders spinulate, a hyaline fin usually present on the postmargin.

Length, 210–350 μ; distance between arms at girdle, 80–120 μ; transdiameter of midbody, 35–40 μ; length of antapicals, 115–260 μ.

Stations, 4594–4713.

Ceratium ehrenbergi, sp. nov.

Plate 2, Fig. 16.

A small species of the *C. lineatum* group with rotund midbody and short horns. Midbody with convex margins and very convex dorsal face, excavated ventrally. Girdle somewhat anteriorly placed, with prominent lists. Apical horn short. Antapicals short, pointed, slightly divergent. Surface with linear striae.

Length, 90–110 μ; transdiameter, 50 μ.

Stations, 4711, 4719.

Ceratium pacificum, Schroeder.

Plate 3, Fig. 21.

A very elongated linear species of the *C. furca* group without expansion of a midbody. Total length, 20–30 transdiameters at the girdle. Epitheca with straight margins tapering evenly from girdle to apical pore. Hypotheca long, nearly two transdiameters in axial altitude. Left horn linear, in length from girdle to apex about 0.3 of the total length. Right horn parallel to left, straight, tapering, scarcely four transdiameters from girdle to its antapex. Postmargin narrow, girdle narrow and with feeble lists, ventral plate elongated, narrow. Chromatophores irregular, dark yellowish brown in color. Varies greatly in length.

Length, 400–775 μ; transdiameter, 27–30 μ.

In Humboldt Current.

Ceratium dilatata (Karsten).

Plate 4, Fig. 25.

A small species resembling *C. platycorne*, but of smaller size, more arcuate postmargin, and more uniformly expanded blade-like antapicals.

The midbody is about the same size as in *C. platycorne*, and passes abruptly into the apical horn, rarely tapering into it as it frequently does in that species. The distinguishing features of the species are the antapicals, which continue from the symmetrically arcuate postmargin to the level of the base of the apical or beyond it, in a regular curve, to a position parallel to the apical or even incurved as in my figure. The ends of the antapicals are not continued in the

parallel direction any considerable distance, and are not so much incurved as they frequently are in *C. platycorne*. The antapicals are flattened, of uniform width, or expanded very slightly towards the antapex. The tips are rounded, squarish, or truncate, rarely asymmetrically pointed.

Length, 95–135 μ; greatest lateral extension, 65–90 μ.

Station, 4732.

Ceratium lanceolatum, sp. nov.

Plate 3, Fig. 17.

A small species related to *C. furca*, without differentiated apical horn.

The epitheca is not constricted to form an apical horn, but the midbody extends to the apical pore or nearly to it. The apical pore is oblique or strictly terminal. The sides of the epitheca are convex, or in some cases slightly concave distally on the left side, as in *C. scapiforme*.

The hypotheca is low, its axial altitude equalling or exceeding the transdiameter. Antapicals short, stout, and straight, the right about half the length of the left.

Length, 95–122 μ; transdiameter, 19–22 μ.

Stations, 4717–4719.

Ceratium pennatum, sp. nov.

Plate 2, Figs. 12, 13, 14.

An elongated species of the *C. furca* group with elongated left antapical curved to the left and dorsally. Long apical, which is straight or curved evenly and but slightly to the left. Short right antapical usually present. An exceedingly variable species.

The midbody is quite variable in form, scarcely swollen in some cases, and merging gradually into the stout apical horn (*propria*, forma nov., Plate **2**, Fig. 12) or more or less swollen, both hypotheca and epitheca being enlarged as they approach the girdle, and more or less sharply delimited from the horns in which they are continued (*inflata*, forma nov., Plate **2**, Fig. 13). The species also varies in the curvature of the left antapical. This is gradual and distributed throughout most of the length in many individuals. In others it is limited to a short abrupt curve at the antapex (*falcata*, forma nov., Plate **2**, Fig. 14). This form is, as a rule, about half the size of f. *propria*, and may prove to be a distinct species. The length of the right antapical is also subject to great variation, being usually fairly well developed, though rarely attaining to a length of 0.5 of a transdiameter.

The concave faces of the curved horns are often greatly thickened in both the apical and left antapical.

This species differs from *C. strictum* (Okamura and Nishikawa) in the curvature of its horns, and from *C. bigelowi*, sp. nov. in the fact that its greatest transdiameter is at the girdle or very close to it.

Length, 360–1225 μ; transdiameter, 25–50 μ.

At many stations between 4574–4684.

Ceratium schroeteri, Schroeder.

Plate 3, Figs. 18, 19.

A small species resembling *C. digitatum*, but with less lateral expansion of the epitheca and less curvature of the antapicals than is found in that species.

Elongated, transdiameter at girdle 0.15 of the total length. Epitheca broad, tapering a short distance from the apex to a short, scarcely delimited apical horn, slightly scoop-shaped and twisted to the left. Antapical horns unequal, the end of the right 1.5 and of the left 2.4 transdiameters from the girdle at the lateral margin. The right horn is straight and tapering; the left is strongly curved dorsally and to the left, and the wall of its concave face is strongly thickened. Thecal wall, of the left antapical especially, scabrous with small spinules at the pores. Chromatophores numerous, irregular.

Length, 335 μ; transdiameter at girdle, 50 μ.

Station, 4594.

Ceratium scapiforme, sp. nov.

Plate 3, Fig. 23.

A species of from small to medium size, of the *C. furca* group showing affinities to both *C. pennatum* and *C. schroeteri*. With long tapering blade-like epitheca not inflated beyond the transdiameter at the girdle, a short oblique scarcely differentiated apical horn, elongated left antapical, and submedian girdle.

The epitheca is 10–11 transdiameters in altitude and its wall is thickened in the region of curvature on the concave face. The apical pore is oblique, opening antero-dextrally. The hypotheca is short in altitude, scarcely more than a transdiameter to the middle of the postobliquity. The right antapical is short and straight, its antapex being about a transdiameter from the girdle. The left antapical is curved dorsally and to the left throughout its length, the curvature near its base being somewhat greater than it is distally. The concave faces of both apical and left antapical horns have thickened walls.

Length, 460–530 μ; transdiameter, 25 μ.

Stations, 4719, 4740.

Ceratium tricarinatum, sp. nov.

Plate 3, Fig. 20.

A medium-sized species of the *C. furca* group with affinities to *C. bigelowi*, *C. digitatum*, and possibly *C. geniculatum*. Distinguished by the inflation of the epitheca into a tricarinate expansion which in its greatest transdiameter equals or exceeds that at the girdle.

One of the carinae is middorsal, and the other two latero-ventral, with sutures of the apical plates at two of the angles. The third suture is midventral. The three faces of the midbody are concave, especially anteriorly. The expansion tapers more or less abruptly into the apical horn and bends somewhat to the left as it passes into the horn, which is straight but directed a little ventrally from the axis.

The hypotheca is very short, scarcely a transdiameter in axial length. The left antapical is long, nearly equalling the altitude of the epitheca in length. It is curved more or less evenly to the left and dorsally. The right antapical is short, straight, a little more than a transdiameter in length, subparallel to the left horn or divergent.

Length, 270–350 μ ; transdiameter at girdle, 35–40 μ.

Stations, 4709–4736.

Peridinium fatulipes, sp. nov.

Plate 5, Fig. 30.

A medium-sized species of the *P. divergens* group characterized by its widely divergent, heavily reticulate antapicals with wide postmargin. It differs from *P. elegans* in its more divergent, widely set antapicals, and from *P. grande* in these same particulars, and also in its smaller size and in the peculiar distribution of its minute pores.

The body is elongated, its length 1.6 times the transdiameter and 2.5 times the dorso-ventral. Epitheca equals the hypotheca, both ventrally excavated. The epitheca resembles that of *P. grande* in proportion, having deeply concave lateral faces and long attenute apical horn.

The hypotheca is contracted to 0.5 of the transdiameter, above the level of the base of the antapicals, which are slender, tapering, and widely divergent, their length 0.4 of a transdiameter, and the distance between their tips 0.8–0.9 of a transdiameter. The postindentation is 0.3 of a transdiameter in depth, forming a broad arc, notched by the longitudinal furrow, as seen ventrally.

The girdle is narrow, slightly impressed, with low membranous ribbed lists, with little displacement or forming a slight ascending right spiral. Longitudinal furrow with high lists not projecting posteriorly beyond the postmargin.

Plates normal, three in middorsal series. Sutures with very broad bands of intercalary striae. Plates centrally reticulate with minute subequal irregular polygons, with minute pores irregularly distributed, not centrally located in the polygons, and not in the mesh itself.

Length, 147 μ ; transdiameter, 100 μ.

Station, 4732.

Peridinium grande, sp. nov.

Plate 5, Fig. 28.

A very large species of the *P. divergens* group with wide flaring girdle and long horns.

Body elongated, length 1.2–1.4 times the transdiameter and 2–2.3 times the dorso-ventral. Epitheca equals the hypotheca, girdle section very broadly reniform. Epitheca a very low cone with very flaring base, and dorsally set tapering apical horn, its altitude 0.6 of its transdiameter. Sides deeply concave.

Hypotheca less abruptly contracted than the epitheca, its transdiameter at base of the horns 0.33–0.4 of that at the girdle. Its altitude is 0.66–0.75 of

its transdiameter. The antapicals are slightly unequal, divergent, conical, acute, their length 0.35–0.45 of the transdiameter. The distance between the antapices is 0.38–0.45 of the transdiameter and is 1.3–1.5 times the depth of the postindentation which is subacute with nearly straight sides.

The antapicals diverge less than in *P. fatulipes*.

The girdle is narrow, median, nearly horizontal, furrow ribbed, scarcely impressed, not displaced, with low membranous ribbed lists. Longitudinal furrow with high membranous lists projecting posteriorly beyond the postmargin.

Plates normal, 3 in median dorsal series. Thecal wall faintly and minutely reticulate with small subequal polygons with very minute centrally located pores.

Length, 185–245 μ; transdiameter, 150–195 μ.

Stations, 4732, 4740.

Peridinium latissimum, sp. nov.

Plate 5, Figs. 31, 32.

A small species with foreshortened, dorso-ventrally flattened body and widely separated very short or obsolete antapicals.

Body pentagonal in face view, anterior margins straight, postero-laterals convex, posterior concave. Its length, 0.8 of the transdiameter and 2.6 times the dorso-ventral. Epitheca, exceeding hypotheca, a low flattened cone, concave ventrally, convex dorsally, its altitude 0.4 of its transdiameter.

Hypotheca low, its altitude 0.45 of its transdiameter, equalling the distance between the low acute antapicals which in some individuals are almost obsolete.

Girdle narrow, almost horizontal, slightly postmedian, furrow deeply impressed, scarcely displaced.

Sutures marked by narrow bands, plates normal, 3 on dorsal side of epitheca. Surface minutely reticulate.

Length, 112 μ; transdiameter, 89 μ; dorso-ventral, 35 μ.

Stations, 4671, 4709.

Peridinium longispinum, sp. nov.

Plate 5, Fig. 33.

Syn. *P. michaelis* Ehrbg. in part, Stein ('83), Taf. IX, Figs. 9 and 11.

A small species of the *P. pellucidum* group with two intercalary middorsal plates, attenuate apical horn, and two long slender finned antapical spines.

Body elongated, flattened dorso-ventrally, its total length including spines 1.2–1.5 times the transdiameter. Epitheca exceeds the hypotheca, is compressed conical with concave lateral faces, and attentuate apical 0.15–0.4 of a transdiameter in length. The altitude is 0.6–0.8 of the transdiameter.

The hypotheca is low, subtruncate posteriorly, with slightly concave post-

margin. It is excavated ventrally, and its left lateral face is nearly straight while its right one is concave. Its altitude, excluding spines, is 1.2–1.35 transdiameters. Antapical horns are not developed, but from the postangles arise two subequal, solid, acicular, finned spines which are slightly divergent. Their length is 0.2–0.45 of a transdiameter.

The girdle is postmedian; the transverse furrow is not indented, and forms an ascending right spiral displaced distally less than its width. It has hyaline ribbed lists. The longitudinal furrow reaches the postmargin, is expanded distally, but its low lists do not as a rule project beyond the postmargin.

Sutures with striate intercalary bands, surface of plates sparingly porulate.

Length, 60–105 μ; transdiameter, 50–85 μ.

Stations, 4613, 4711.

Peridinium murrayi, sp. nov.

Plate 5, Fig. 29.

Syn. *P. divergens*, Ehrbg. in Murray and Whitting ('99), Pl. 29, Fig. 4.

A large species resembling *P. oceanicum*, but differing from it in the much lower epitheca with more concave sides, longer apical horn, and longer and more divergent antapical horns.

Body compressed dorso-ventrally, dorso-ventral diameter 0.65 of the transdiameter, and about equal to the length of the apical, or either of the antapicals. Distance between the tips of the antapicals equals or exceeds the transdiameter.

Girdle nearly median, furrow not impressed, with high membranous ribbed lists, forming a descending right spiral displaced twice its width. Longitudinal furrow with high lists which project beyond the postmargin.

Chromatophores radiating, linear.

Length, 250 μ; transdiameter, 135 μ.

Station, 4736.

Peridinium tenuissimum, sp. nov.

Plate 5, Fig. 34.

A minute hyaline species related to *P. pedunculatum*, but distinguished by its smaller size, more elongated body, and longer apical horn and antapical spines.

The length of the midbody excluding horn and spines exceeds the transdiameter. The midbody is broadly ovoid, passes abruptly into the cylindrical apical horn, whose length is but little less than a transdiameter. It flares slightly at the apical pore. The acicular divergent antapicals are nearly a transdiameter in length. The girdle is median on the midbody and is not displaced. The lists of the longitudinal furrow extend beyond the postmargin. The whole organism is exceedingly hyaline, plates and sutures not determinable.

Length, excluding antapical spines, 45–50 μ; transdiameter, 25–28 μ.

Station, 4711.

Heterodinium agassizi, sp. nov.

Plate 6, Fig. 35.

A small species with very broadly rounded apex, scoop-shaped epitheca, and subequal antapicals. The bifurcation is deep and evenly rounded. The reticulations are of medium size and fairly regular.

The epitheca is broad, its apex almost a semicircle, with a slight constriction some distance in front of the girdle but not so deep as in *H. fides*. Ventral surface concave. Altitude of epitheca on ventral face 1.16 times the transdiameter at the girdle, on the dorsal 0.82 times. Ventral area elongated, pit at its anterior end.

Hypotheca about equal to the epitheca. Its lateral margins nearly straight, convergent, distance between the tips of the antapicals a little less than 0.5 of a transdiameter. Postindentation deep, axial depth about 0.5 of a transdiameter, evenly rounded. Antapicals subequal, acute, scarcely spreading. Ventral face deeply impressed about the longitudinal furrow. Girdle narrow, oblique, displaced its own width, coarsely reticulate; not deeply impressed, ridges low.

Thecal wall reticulate with polygons of medium size, which are subregular along the margins. Reticulations porulate. Marginal sutures very heavy. Below the girdle on the dorsal side there are 34 contiguous reticulations and about 130 in the dorsal apical plate. Plates normal, obscure on ventral face of hypotheca.

Chromatophores bright cadmium yellow.

Length, 155 μ; transdiameter, 78 μ.

Station, 4699.

Heterodinium calvum, sp. nov.

Plate 7, Fig. 43.

A large spheroidal species with wide girdle and smooth wall.

Body spheroidal, flattened a little on the ventral face. Epitheca hemispheroidal, with rounded apex, flaring a little at the girdle. The ventral pit is median, in a quadrangular ventral area. The hypotheca is also hemispheroidal, with flattened antapex, with angular outline. It is excavated ventrally. The girdle is median, is very wide, especially in the distal half. The transverse furrow is impressed and the anterior ridge has considerable overhang. It forms a descending right spiral displaced its own width. The longitudinal furrow is slender, narrow, and extends but little beyond the posterior list of the distal end of the girdle.

The thecal wall is smooth, suture lines faintly marked, or with low ridges spinous in places, on the ventral face of the hypotheca. Porulate, but without other surface modification.

Length, 75 μ; transdiameter, 75 μ.

Station, 4739.

Heterodinium curvatum, sp. nov.

Plate 8, Fig. 48.

A large species with tapering epitheca deflected to the right, salient girdle, widely separated spreading antapicals with slightly incurved tips.

Body elongated, length nearly twice the transdiameter at the girdle, and nearly three times the greatest dorso-ventral extension. Epitheca contracted regularly from the base to the apical pore. Right margin somewhat concave, the left nearly straight, a feebly developed apical horn inclined to the right. Altitude about equals the transdiameter. Ventral area squarish, pit nearly central.

Hypotheca shorter than epitheca on ventral face, equal to it on the dorsal. Its altitude less than a transdiameter. More abruptly contracted than the epitheca to the base of the antapicals, which diverge but have incurved tips. Distance between the tips 0.6 of a transdiameter. Postindentation moderate, axial depth 0.4 of a transdiameter, the postmargin a very broad curve. Antapicals subequal, elongated, tapering, acute.

Girdle oblique, displaced its own width, obsolete distally, its posterior list decurrent on the right antapical. Furrow deeply impressed, with salient ridges partially reticulate.

Thecal plates normal ; sutures marked by smooth bands, or bands of minute polygons. Lateral sutures with high lists. Reticulations somewhat deficient on tips of apical and antapical horns and midcentral region of hypotheca. Reticulations relatively small, porulate, subequal, elongated and subregular along the lateral margins. About 150 reticulations on the dorsal apical plate and 34 contiguous to the girdle on the dorsal side.

Length, 235 μ ; transdiameter, 127 μ.

Station, 4699.

Heterodinium expansum, sp. nov.

Plate 6, Fig. 36.

A small species with short, stout, widely separated antapicals, nearly straight postmargin, and very oblique girdle.

The body is stout, its length being 1.3 transdiameters. It is strongly flattened dorso-ventrally, its greatest dorso-ventral extension being only 0.28 of a transdiameter. The girdle is very oblique, its antero-posterior extension being 0.3 of the total length. It is nearly median in position.

The epitheca is broadly rounded anteriorly in ventral view and passes abruptly into the short apical horn, which is deflected a little to the right and ventrally. Its altitude is 0.6 of a transdiameter and its ventral face flattened. The ventral area forms an elongated tract in the centre of the ventral face, and the ventral pit is located anteriorly in this area.

The hypotheca is convex laterally, excavated ventrally, with short, stout, acute, subequal antapical horns 0.18 of a transdiameter in length. The post-

margin is straight or nearly so, horizontal, and equals the axial altitude of the hypotheca in length.

The transverse furrow is not impressed, its posterior list is absent, and it forms a descending right spiral displaced distally its own width. The longitudinal furrow extends but half-way to the postmargin and is very narrow.

The left intercalary plate is large. Suture lines are marked by ridges. Thecal wall reticulate, with coarse, irregular, unequal polygons.

Length, 105 μ; transdiameter, 80 μ.

Station, 4637.

Heterodinium fenestratum, sp. nov.

Plate 8, Fig. 47.

A small species of robust habit, rotund body, short incurved antapicals, very coarse reticulations, and deficient posterior list to the girdle.

The body is very robust, the length being 1.36 times the transdiameter and 1.6 times the dorso-ventral diameter. The epitheca is abruptly contracted from the spreading girdle to a tapering apical horn which terminates in a large oblique or squarely truncate apical pore. Its altitude is 0.70–0.75 of a transdiameter. Its margins are in all views deeply concave. The ventral excavation is not marked. The ventral area is squarish with central pit.

The hypotheca is a little smaller than the epitheca, its altitude being about 0.45 of the total length. It is contracted less abruptly than the epitheca, having a width of 0.55 of a transdiameter at the level of the postindentation. The sides of the antapicals are nearly parallel to the main axis. The antapicals are short, stout, acute. The postindentation is very shallow, being 0.2–0.26 of a transdiameter in depth. The postmargin is a broad, quite regular curve.

The girdle is wide, is displaced 1.5–2 times its own width, slightly impressed, if at all, and bears a regular series of large reticulations. Its anterior ridge is heavy and ribbed, and the posterior one is obsolete or scarcely developed.

The plates are normal. The left intercalary is very small, embracing but one or two reticulations. The marked characteristic of the species is the very coarse reticulations each of which has 1–10 pores. There are 17 reticulations on the dorsal apical plate and 8 contiguous to the posterior margin of the girdle on the dorsal side. Suture lines are marked by very wide bands.

Length, 95–105 μ; transdiameter, 70–77 μ.

Stations, 4730, 4742.

Heterodinium fides, sp. nov.

Plate 7, Fig. 45.

A small species with constricted scoop-shaped epitheca, wide salient girdle, and short, divergent, subequal antapicals.

Body stout, its length 1.5 times the transdiameter and 2 times the greatest

dorso-ventral extension. Epitheca scoop-shaped, excavated ventrally, flaring at the girdle. Its altitude 0.75 of a transdiameter. Apex with broadly sloping slightly convex margins, which turn abruptly posteriorly to a broad, deep constriction just below the level of the ventral area, below which it abruptly expands to the girdle, thus giving to the epitheca a form which suggests the body of a violin. The ventral area is ellipsoidal, with the pit at its anterior end.

The hypotheca is somewhat shorter than the epitheca, its ventral altitude being less than 0.75 of a transdiameter. It is constricted somewhat rapidly, reaching 0.5 of a transdiameter at the level of the base of the antapicals. The antapicals are short, stout, acute, and divergent, their tips being less than 0.5 of a transdiameter apart. The postindentation is less than 0.25 of a transdiameter in depth and is broadly rounded.

The girdle is but slightly oblique, is displaced its own width, and is obsolete distally, its posterior ridge being decurrent on the right antapical. The furrow is deeply impressed, has very prominent ridges and coarse reticulations.

The thecal plates are normal. The left intercalary plate of the epitheca is unusually large. The reticulations are porulate, relatively large, and somewhat irregular.

Length, 123 μ; transdiameter, 83 μ.

Station, 4228.

Heterodinium gesticulatum, sp. nov.

Plate 6, Figs. 37, 38, 39, 40.

A medium-sized species with rounded apex, right antapical deflected strongly to the right and the posterior angle of the postcingular plates on the left margin of the hypotheca strongly protuberant.

Body moderately elongated, the length 1.6 to 2.3 times the transdiameter (measured on the anterior ridge of the girdle). The epitheca is shorter and distinctly wider than the hypotheca. Its apex is broadly rounded, almost semicircular in face view, but the ventral face is not deeply excavated or scoop-shaped. It is often wider anteriorly than it is at the girdle, and may have a slight constriction just anterior to the girdle. The ventral area is irregularly squarish with central pit.

The hypotheca is narrower than the epitheca, its transdiameter at the girdle being 0.9 to 0.75 of that of the epitheca. Its ventral surface is flattened, the dorsal one rotund. The posterior part of the hypotheca beyond the suture between the postcingular[1] and antapical plates is deflected to the right, in extreme cases as much as 40°. The right antapical is deflected more than the left, attaining even 45° to the main axis, while the left is only 5°-10° or subparallel to the axis. The right margin of the epitheca is deeply concave, while the left is carried out in a more or less prominent, often decurved angle at the point just anterior to the suture between the left postcingular and the left ant-

[1] These plates were called postmedians in my earlier paper (:05), On Heterodinium, etc., Univ. of Calif. Pubs. Zoöl., 2, p. 345.

apical plates. This salient angle is the most striking feature of the species. The antapicals are short or more or less elongated, acute, and divergent. The postindentation is deep or shallow, being 0.2–0.8 of a transdiameter (of hypotheca) in depth. The postmargin forms a broadly rounded or subacute bay, with a hyaline irregularly toothed fin along most of the margin.

Girdle slightly oblique, displaced a little less than its width, obsolete distally. Anterior ridge very heavy, posterior one scarcely developed.

The plates are normal, the left intercalary being relatively large. The sutures are marked by prominent ridges, or by broad bands with or without fine reticulations. Thecal wall porulate, covered with reticulations of medium size. About 20 contiguous to the posterior side of the girdle on the dorsal side in the dorsal apical. Reticulation often lacking on some of the plates.

Chromatophores few, centrally located, spheroidal. Sometimes massed in chromospheres.

This is the most abundant species of the genus in tropical waters. It is exceedingly variable, but the diverse forms are so well connected by intermediates that they must be regarded as one species. The following forms may be recognized: —

Forma *typica* (Plate 6, Fig. 37). With little constriction of epitheca, moderate marginal projection of the left postcingulars and postindentation.

Forma *extrema* (Plate 6, Fig. 38). With constricted epitheca and relatively narrow hypotheca, excessive marginal projection and deep postindentation, and considerable obliquity of the hypotheca.

Forma *mediocris* (Plate 6, Fig. 39). With little deflection of hypotheca and antapicals, less inequality in transdiameters, slight marginal projection, and often with moderate subacute postindentation.

Forma *deformata* (Plate 6, Fig. 40). With right or left antapical undeveloped.

Length, 118 to 170 μ; transdiameter of epitheca, 67 to 100 μ; of hypotheca, 48 to 91 μ.

At various stations between 4594 and 4724.

This species (forma *extrema*) is figured in Capt. R. F. Scott's "Voyage of the Discovery," Vol. 2, on the plate facing p. 192 under the legend "Peridineans caught on the voyage out."

Heterodinium globosum, sp. nov.

Plate 8, Fig. 51.

A small species with rotund body, short apical horn, and small spine-like antapicals, deficient list, and sparse reticulations.

The body is spheroidal, the length (excluding apical and antapical horns) about equals the transverse and dorso-ventral diameter. The total length is 1.3 times the transdiameter and 1.5 times the dorso-ventral. The epitheca is dome-shaped, flaring at the girdle, and constricted apically to a short, stout horn

with oblique apical pore deflected to the right. The ventral area is poorly defined and the pit is located far anteriorly.

The hypotheca is low dome-shaped with two short, acute, unequal, widely separated divergent antapicals. The left is 2–3 times the length of the right, and the distance between their tips is 0.45 of a transdiameter. The postindentation is very shallow and the postmargin a broad, irregular curve.

The girdle is slightly oblique, is displaced less than its own width, lacks the posterior list entirely. The furrow is not impressed, and is marked by sparsely distributed reticulations.

The plates are normal. The left intercalary is of medium size. The wall is porulate in the central areas of the plates, which are imperfectly reticulate or bounded by ridges. The suture lines are bounded by broad, structureless bands.

Length, 117 μ; transdiameter, 82 μ.

Stations, 4691, 4692, 4699.

Heterodinium hindmarchi, forma maculata, f. nov.

Plate 7, Fig. 42.

Distinguished from the typical *H. hindmarchi* by the character of the reticulations. The form, proportions, and dimensions resemble those of the species named, but the reticulations are entirely different. In the type they are coarse and subregular. In f. *maculata* they are exceedingly diverse in size. Distally on the apical and antapicals, the minute reticulations predominate. In the pre- and postcingular plates they are predominately marginal in the plates or intercalated in more or less complete horizontal series. They are also found in isolated and irregular groupings. Possibly such differences here constitute a specific distinction.

Length, 140 μ; transdiameter, 80 μ.

Station, 4691.

Heterodinium laticinctum, sp. nov.

Plate 7, Fig. 46.

A moderately large species with very oblique, very wide girdle, broadly rounded apex, angular hypotheca, and incurved unequal antapicals.

The body is robust, ovate in ventral view, its length 1.4 times the transdiameter and 1.8 times the dorso-ventral. The apex is semicircular in outline.

The epitheca is low scoop-shaped with slight excavation, foreshortened dorsally so that the dorsal precingulars are scarcely as wide as the girdle. The apical pore is displaced to the right. The ventral area is displaced to the left, is subcircular with eccentric pit.

The hypotheca is a little longer than the epitheca. Its sides are slightly convex, and the antapicals are incurved and very acute. The left is twice the length of the right. They arise toward the ventral face and make a sharp offset dorsally to meet the postcingular suture.

The postindentation is shallow, about 0.25 transdiameter in depth, and the postmargin is squarish, with serrate fin.

The girdle is very oblique, displaced its own width, has low anterior and posterior lists, the latter decurrent on the left antapical. The furrow is slightly impressed and bears a few transverse ribs.

The plates are normal, the left intercalary being very small. The sutures are marked by ribs which locally bear hyaline serrated lists. Plates porulate. Reticulation lacking on specimen seen.

Length, 148 μ; transdiameter, 105 μ.

Station, 4724.

Heterodinium longum, sp. nov.

Plate 7, Fig. 44.

A medium-sized species resembling *H. rigdenae* but more elongated, with deeper postindentation and higher epitheca. It also resembles *H. hindmarchi*, but can be distinguished from it by its wider epitheca with straighter sides and the absence of convergence in the antapicals.

The body is elongated, its length 1.5 times its transdiameter, compressed dorso-ventrally. The epitheca exceeds the hypotheca, its length being about 0.6 of the total length. It is compressed conical, with straight margins and apical but little deflected to the right. The ventral area is squarish and deflected to the left with eccentric pit.

The hypotheca is contracted more than the epitheca, is convex anteriorly and concave posteriorly at the margins. The antapicals are pointed, stout, divergent, and subequal, the left often larger. The postindentation is deep, exceeding 0.5 of the altitude of the hypotheca. The postmargin is broadly rounded, and the tips 0.5 of a transdiameter apart.

The girdle is slightly oblique, displaced its own width, with slight anterior ridge and deficient posterior list obsolete distally. The furrow is not impressed and is more or less ribbed.

The plates are normal, suture lines well defined. Plates porulate, with coarse regular reticulations.

Length, 93–125 μ; transdiameter, 65–90 μ.

Stations, 4732, 4734, 4742.

Heterodinium obesum, sp. nov.

Plate 8, Fig. 50.

A minute species with spheroidal body, prominent apical horn, large hypotheca, and very unequal antapicals.

The body is robust; excluding all of the horns it is almost a sphere. The total length is 1.3 times the transverse or the dorso-ventral diameter. The epitheca is a low cone with slightly flaring base, nearly straight sides, and apex displaced ventrally. The total altitude is 0.6 of its transdiameter,

and the distance to the base of the horn 0.35 of the transdiameter. The apical pore is inclined a little to the right.

The ventral area is not strongly defined and the pit is not far removed from the girdle.

The hypotheca is very rotund, its greatest diameter being slightly below the girdle. Its total altitude is 0.8 of its transdiameter at the girdle, and its axial altitude 0.6. The left antapical is longer than the right and is formed by a blunt protuberant lobe whose width is half its height, bearing on its broadly rounded antapex a one or two-ribbed fin strongly deflected to the right. The right antapical is nothing but a finned spinule arising from the body, also deflected to the right.

The girdle is not oblique save in the distal third, where it is so deflected posteriorly that its displacement is twice its width. The anterior ridge is heavy, the posterior obsolete. The furrow is not impressed and is faintly ribbed.

The plates are normal, the left intercalary large, subtriangular. The suture lines are faint, marked by structureless bands. The plates are porulate with or without faint reticulations of relatively large size.

Length, 50 μ; transdiameter, 37 μ.

Station, 4734.

Heterodinium praetextum, sp. nov.

Plate 7, Fig. 41.

A very large species of the subgenus *Euheterodinium* with slender, tapering, apical horn developed to a degree unusual in the genus.

The body is elongated, its length 1.3 times the transdiameter and 1.7 times the dorso-ventral. Epitheca exceeds the hypotheca in ventral view, and equals it dorsally. Its altitude is 0.8 of its transdiameter at the base, its ventral face is excavated, its laterals convex in the median region and concave distally, and the dorsal nearly straight. The apical horn is deflected to the right, and its length is 0.25 of the altitude. The midventral suture is strongly deflected to the left basally, and the ventral area is elongated, oblique, with eccentric pit.

The hypotheca is broadly excavated ventrally, abruptly contracted dorsally, and with feeble double curves laterally. The postindentation is shallow, forming an asymmetrical arc, its depth 0.3 of the altitude of the hypotheca. The antapicals are short, stout, bluntish.

The girdle is slightly oblique and postmedian, forming a descending right spiral displaced distally its own width. The furrow is scarcely impressed, with deflected posterior list obsolete distally and decurrent on left antapex.

The longitudinal furrow is short with low lists.

The thecal plates are normal, and the walls reticulate with subequal, subregular polygons which become smaller distally on the horns. The suture lines are marked by broad bands with imperfectly developed areas of minute reticulations.

Length, 240 μ; transdiameter, 180 μ.

Station, 4740.

Heterodinium superbum, sp. nov.

Plate 8, Fig. 49.

A very small species of robust habit, spheroidal body, and short spine-like antapicals. Reticulations rather coarse.

The body is elongated spheroidal, its length 1.28 times the transdiameter and 1.35 times the dorso-ventral diameter. The body is very rotund at the girdle. The epitheca and hypotheca are equal in length, but the latter is more rotund. The epitheca is subconical, its altitude is 0.56 of its transdiameter. It flares slightly at the girdle and its lateral margins have but little convexity. There is a partially developed apical horn, deflected to the right and set somewhat to the ventral side of the axis.

The hypotheca is very rotund, low dome-shaped, its altitude between the horns being a little less than 0.5 of its transdiameter. The antapicals are set to the ventral side in line with the apical, causing an abrupt shelf where the dorsal antapical plate joins the postcingulars. The right is 1.15 times the length of the left, which is 0.2 of a transdiameter in length. They are tapering, spine-like, with 0.3 of a transdiameter between tips. The postindentation is very shallow and the postmargin a broad curve.

The girdle is not oblique, is displaced its own width. The anterior list is very heavy, the posterior light and obsolete distally. The furrow is scarcely impressed and is heavily ribbed.

The plates are normal, the left intercalary triangular in form. The thecal wall is coarsely reticulate and porulate. There are about 30 reticulations in the dorsal apical and 15 contiguous to the girdle on the dorsal side. Suture lines with narrow ridges, minor reticulations or serrations.

Length, 74 μ; transdiameter, 59 μ.

Station, 4699.

CENTRODINIUM, gen. nov.

Steiniella (?) Cleve.

Ceratiinae with laterally compressed midbody contracted to an apical horn with pore and a single median antapical, median girdle on midbody, transverse furrow impressed, forming a descending right spiral. Longitudinal furrow mainly confined to hypotheca. Theca fully divided in discrete plates. Suture lines faint. Epitheca composed of apical and precingular series, 2 plates (possibly 4) in the former, and 6 in the latter. Girdle not distinctly divided into constituent plates. Hypotheca composed of 5 precingulars, 4 antapicals, and one dorsal intercalary. Thecal wall hyaline, structureless, porulate. Small ventral pore above the flagellar pore. Chromatophores present.

In warm temperate and tropical seas.

Centrodinium complanatum (Cleve).

Steiniella (?) *complanata*, Cleve.

Length 4–5 times dorso-ventral diameter. Midbody not abruptly set off from apical or antapical. Antapex not deflected to the left, bearing three short spinules. Apex and antapex coarsely porulate, the former not abruptly truncate.

Length, 300–400 μ ; dorso-ventral diameter, 75–80 μ.

Station, 4719.

Centrodinium deflexum, sp. nov.

Plate 9, Figs. 53, 54.

A medium-sized species with narrow apical, and antapical abruptly deflected to the left at an angle of 45°.

Body not greatly elongated, length 1.3 times the dorso-ventral diameter and 7 times the transdiameter. Epitheca and hypotheca nearly equal. Midbody laterally compressed, not flaring at the girdle laterally, dorsal and ventral margins both convex, epitheca abruptly contracted to the slender apical horn whose length is 0.5–0.12 of the transdiameter in length and broadly rounded at the end. This horn is directed obliquely dorsally in line with the trend of the ventral margin.

The hypotheca resembles the epitheca in proportions in lateral view, but the antapical horn is directed ventrally subparallel to the direction of the apical. In side view this is seen to be bent abruptly to the left as it leaves the midbody, at an angle of about 45°. The antapex bears 3 short spinules, 1 on the left and 2 on the right side.

Thecal wall hyaline, porulate, structureless, sutures faintly marked, apical and antapical regions coarsely porulate.

Length, 145–200 μ ; dorso-ventral diameter, 66–75 μ.

Stations, 4730, 4732.

Centrodinium elongatum, sp. nov.

Plate 9, Fig. 52.

A large species with truncate apex, epitheca shorter than hypotheca and long antapical horn.

Body elongated, length 3–4 times the dorso-ventral diameter and 7 times the transverse. Epitheca 0.3 of the total length, laterally compressed, flaring abruptly laterally to the girdle, ventral margin nearly straight, dorsal convex. Apical horn stout, short, abruptly truncate, its length equal to or exceeding its dorso-ventral width, and 0.35 of the dorso-ventral diameter in width.

Hypotheca greatly elongated, tapering within a transdiameter of the apex into the stout elongated antapical horn, its length 1.7–3 times its dorso-ventral diameter. Antapical horn cylindrical, curved to the left in a slight gradual curve, apparently twisted, terminating in three acute spinules.

Girdle narrow, median in the midbody, impressed, without salient ridges, forming a descending right spiral, displaced its own width. Longitudinal furrow extending a short distance on the epitheca where it contains an accessory ventral pore and is continued posteriorly on the midbody as a diminishing groove nearly to the base of the antapical.

Thecal wall hyaline, finely porulate, larger pores on apex and antapex. Dorsal wall of apical greatly thickened.

Length, 275 μ; dorso-ventral diameter, 67 μ.

Station, 4722.

This is the type species of *Centrodinium*.

Podolampas reticulata, sp. nov.

Plate 2, Fig. 11.

A large species with the form of *P. biceps*, but with reticulate fins on the antapical spines. Their fins are very large and broadly rounded, with irregularly serrate margins and distal reticulations spreading from the spines. The fins are more decurrent laterally and less pointed than in *P. biceps*, and the spines 0.5–0.7 as long. The body is a trifle shorter and somewhat more rotund anteriorly and less squarish posteriorly.

Length of body, 80–92 μ; transdiameter, 70–75 μ.

Stations, 4638, 4732.

Oxytoxum challengeroides, sp. nov.

Plate 10, Fig. 65.

A medium-sized species resembling *O. milneri*, but shorter, with fine regular polygonal reticulations resembling those of the *Challengeridae*.

Body elongated, its length 3.7 times the transdiameter, which equals the dorso-ventral at the girdle. Epitheca 0.4 of the length of the hypotheca, low conical, flaring at the base, its altitude 1.17 times the transdiameter, tapering quickly into the short straight apical horn, which is displaced ventrally and has an asymmetrically pointed apex, the terminal spinule being on the left margin of the horn.

Hypotheca conical, with slightly convex sides, tapering without constriction into the pointed antapical, which is also somewhat displaced ventrally.

Girdle wide, 0.33 of the length from the apex, furrow deeply impressed, with well-defined margins, forming a descending right spiral displaced nearly its own width. Small accessory pore in its posterior margin in the midventral line behind the large flagellar pore. Longitudinal furrow not extended upon the hypotheca, with a tapering lanceolate extension 0.6 of the distance to the apex on the epitheca.

Plates normal, 5 apicals, pre- and postcingulars, one apical spine. Sutures with narrow bands, thecal wall minutely and subregularly reticulate with small hexagonal polygons, porulate.

Length, 80 μ; dorso-ventral diameter, 23 μ.
Station, 4732.

Oxytoxum compressum, sp. nov.

Plate 10, Fig. 63.

A medium-sized species resembling *O. cristatum*, but lacking the galeate apex, and having the antapical horn strongly deflected to the ventral side.

Body elongated, laterally compressed. Total length 2 times the transdiameter and 1.6 times the dorso-ventral. Epitheca 0.25 the total length, low campanulate or dome-shaped, flaring at the girdle, apex blunt, broadly rounded. Altitude of epitheca 0.5 of the transdiameter and 0.35 of the dorso-ventral diameter.

Hypotheca elongated, its length 1–1.4 times the dorso-ventral and 1.5 the transdiameter. Dorsal and ventral margins somewhat convex, gradually rounded posteriorly to the hook-like ventrally recurved antapical spine. Lateral margin but slightly convex, abruptly contracted to the antapical.

Girdle narrow, horizontal, ribbed, furrow deeply impressed with salient ridges, forming a descending right spiral displaced its own width, without overhang. Longitudinal furrow short, its length 0.3–0.4 of the total length, equally extended on both sides of girdle, both ends expanded.

Pre- and postcingular plates normal, apicals and antapicals not resolved into separate parts. Postcingulars with marginal and median striae, which are faintly outlined on epitheca also. Wall porulate.

Length, 100 μ; dorso-ventral diameter, 62 μ.
Stations, 4699, 4724.

Oxytoxum cristatum, sp. nov.

Plate 10, Fig. 64.

A medium-sized species with elongated laterally compressed body, galeate epitheca, and long antapical spine.

Total length 2.5 times the transverse and 1.85 times the dorso-ventral diameter. Epitheca 0.4 of the total length, helmet-shaped, with flaring base abruptly compressed laterally to a thin dorsally recurved apex. Apex a sharp horizontal, or even posteriorly deflected spine. Transverse diameter of the base 0.75 of the dorso-ventral and 0.9 of the altitude.

Hypotheca tapering obliquely to the ventral side, laterally compressed, lateral margins slightly convex, dorsal broadly rounded, ventral concave, abruptly contracted to a long, tapering, ventrally deflected, antapical spine, 0.4–0.6 of the transdiameter in length.

Girdle narrow, with salient margins, furrow impressed, forming a descending right spiral displaced its own width, no overhang, and with numerous stout ribs. Longitudinal furrow short, length 0.3 of the total length, nearly 0.6 of its course on the epitheca, elongated elliptical in form.

Neither apical nor antapical region resolvable into separate plates. Pre- and

postcingular plates, each with marginal and median rib, sometimes porulate, sometimes with very fine transverse tesselations.

Length, 100 μ; transdiameter, 38 μ; dorso-ventral, 50 μ.

Stations, 4730, 4732.

Oxytoxum curvicaudatum, sp. nov.

Plate 10, Fig. 61.

A minute species of robust habit. Body ellipsoidal, transverse and dorso-ventral diameter equal. Length 1.2 times the transdiameter. Altitude of epitheca scarcely 0.5 of the total length and 0.4 of its transdiameter, in the form of a low dome with blunt apex and convex sides.

Hypotheca over 2.5 times as high as the epitheca, the diameter of its base 1.25 times its altitude. Anteriorly the sides are slightly, if at all, convex. Antapex very broadly rounded, terminating in an acute, minute, antapical spur which is deflected ventrally to a horizontal position.

Girdle about 0.3 of the total length from the apex. Transverse furrow compressed, without lists or salient ridges forming a descending right spiral with displacement twice its width, with slight overhang.

Longitudinal furrow broad and shallow, its length 0.35 of the total length of the body, wider and longer on epitheca than on hypotheca.

Pre- and postcingular plates marked with eleven longitudinal striae, fainter upon the epitheca. Interstrial areas finely reticulated.

Girdle ribbed and areolated.

Length, 41 μ; diameter, 30 μ.

Station, 4711.

Oxytoxum gigas, sp. nov.

Plate 10, Fig. 59.

A very large species of slender habit, attentuate epitheca and hypotheca, galeate apex, and regularly tapering antapex, greatly displaced girdle, and minute pores in longitudinal striae.

The body is nearly biconical, the epitheca about 0.4 of the total length. Total length 4 times the dorso-ventral and 4.8 times the transdiameter. Epitheca subconical with concave sides, very little flare at the base, slight lateral compression, and somewhat elongated slightly galeate apex, broadly rounded and deflected dorsally. Its total altitude 2.2 times its transdiameter at the base.

Hypotheca a regularly tapering cone, slightly compressed laterally. Its total altitude 3.5 times its transdiameter at the base. Antapex not differentiated in form from the postcingular section, forming 0.22 of the total length of the hypotheca.

Girdle very narrow and very oblique ; furrow deep, with prominent but not salient margins, forming a descending right spiral displaced 7 times its own width, with numerous faint ribs and a few pores. Longitudinal furrow narrow,

of uniform width, its length 0.15 of the total length of the body. It extends from the proximal end of the transverse furrow posteriorly to a girdle width beyond its distal end. The flagellar pore lies near the proximal end.

Pre- and postcingular plates normal, sutures indistinct in apex and antapex, but each composed of several plates.

Thecal wall marked by equidistant striae containing regularly spaced pores. The striae along sutures somewhat heavier than the 2–3 intermediate ones on each plate. Striae are interrupted at the transverse sutures between the cingular and the terminal plates.

Length, 267 μ ; transdiameter, 55 μ.

Station, 4732.

Probably *Steiniella mitra* Schütt [1] belongs in *Oxytoxum*.

Oxytoxum subulatum, sp. nov.

Plate 10, Fig. 62.

A large species of slender habit, elongated form, with abruptly contracted epitheca and long subulate apex.

The body is greatly elongated, its length 5–6 times the transdiameter and 4.5–5 times the dorso-ventral. There is little lateral compression. The epitheca is 0.9 of the length of the hypotheca. The epitheca is trumpet shaped with low abruptly contracted basal part and slender linear apical horn with sharp asymmetrical apex shaped like the point of a cannula with the excavation upon the right side, the relative length of the three parts, flaring base, horn and point, are respectively 0.18, 0.58, and 0.24 of the altitude of the epitheca, which is 2.3 times its transdiameter. The horn is set somewhat to the ventral side of the epitheca.

The hypotheca is almost conical, slightly gibbous just below the girdle, more on the ventral than on the dorsal side, contracted as it passes into the slender attenuate antapex. Its altitude is 2.8–3.2 times its transdiameter at the girdle. The antapical horn is slender, straight, its length a little less than 0.5 transdiameters.

The girdle is nearly horizontal, the furrow very deeply impressed with thin, slightly salient ridges, forming a descending right spiral displaced 0.5 of its width.

Apical region formed of 4 slender plates, antapical fused. Thecal wall with 10–12 longitudinal striae. Surface with minute areoles.

Length, 124–142 μ; transdiameter, 21–27 μ.

Stations, 4698, 4699.

Oxytoxum turbo, sp. nov.

Plate 10, Fig. 60.

A minute elongated top-shaped species with capitate epitheca.

Body elongated, its length 2.3 times the greatest transverse diameter, which

[1] Schütt, F. Die Peridineen der Plankton Expedition. Taf. 7, Fig. 27, 1895.

equals the dorso-ventral. The greatest diameter is a short distance posterior to the girdle. The epitheca is a small hemisphere with a short, stout, apical horn with blunt apex. The apical horn emerges very abruptly from the dome of the epitheca. The altitude of the epitheca above the girdle is 0.5 of its transdiameter, which in turn is 0.5 of the greatest transdiameter of the hypotheca, and about 0.16 of the total length.

The hypotheca is top-shaped, abruptly rounded to the girdle, tapering regularly posteriorly to an acute point.

The girdle is peculiar, very wide, its width 0.12 of the total length, and slightly exceeding the altitude of the epitheca. It is constricted to an acute-angled furrow at its middle, and extends anteriorly on the capitate epitheca and posteriorly upon the expanding hypotheca. Its margins are marked by faint lines with a prominent line of pores, especially in the hypotheca, where a low hyaline list also occurs. The list on the hypotheca is very low.

Plates normal, scarcely defined on epitheca, apical horn not separable, antapical also apparently fused. The surface faintly marked with punctate longitudinal striae.

Length, 50 μ; transdiameter, 22 μ.

Station, 4734.

MURRAYELLA, gen. nov.

Oxytoxinae with spheroidal body and medium girdle, epitheca and hypotheca nearly equal. Transverse furrow impressed, forming a descending right spiral with more or less displacement. Longitudinal furrow on both epitheca and hypotheca but not reaching the apex or antapex. Theca composed of discrete plates. Epitheca with 6 precingulars and 2–4 apicals and a small mid-ventral intercalary next to the longitudinal furrow. No apical pore. Hypotheca composed of 5 postcingulars one of which is the longitudinal furrow plate, and an antapical apparently of one spine-like plate. Plates ribbed and reticulate. Chromatophores yellowish.

Ceratium biconicum Murr. et Whitt. and *Steiniella* (?) *punctata* Cleve belong in this genus.

Murrayella globosa, sp. nov.

Plate 9, Fig. 56.

A small globose species with epitheca equalling the hypotheca. Epitheca conical, its altitude 0.6 of a transdiameter. Apex rounded or with small acute point. Hypotheca hemispherical with short acute terminal spine deflected to the right. Left side somewhat more convex than the right. Girdle median, displaced distally its own width. Furrow deeply impressed, without lists or salient ridge, sparingly ribbed. Longitudinal furrow greatly widened on the epitheca, reaching 0.4 of the diameter to the apex and its width nearly equalling its height. Posteriorly the longitudinal furrow is narrow and not so expanded at the end as on the epitheca.

The sutures are marked by ridges with cross striae or by broad intercalary bands. The longitudinal furrow plate of the hypotheca is long and narrow. The postcingulars have a median rib. The surface of the plates is minutely and regularly reticulate. No pores.

Chromatophores small, spheroidal. Large central yellowish chromosphere.

Length, 68 μ; transdiameter, 59 μ.

Station, 4732.

This is the type of *Murrayella*.

Murrayella spinosa, sp. nov.

Plate 9, Fig. 57.

A small species of biconical form with antapical spine resembling *Amphidoma*.

Body biconical, epitheca longer than hypotheca, total length 1.4 times the transdiameter. Epitheca conical, its altitude 0.5 of its transdiameter, sides slightly convex. Antapex with short spine with a transverse fin.

Girdle postmedian, 0.55 of the length from the apex, impressed, without salient ridges, forming a descending right spiral displaced less than 0.5 of its own width, most of the displacement occurring in the *proximal* part of the furrow. Longitudinal furrow on the epitheca only a narrow groove terminating in a pit, on hypotheca two girdle widths in length with marginal lists.

Plates normal. Suture lines with broad reticulated bands and central seam. Plates finely reticulate with irregular polygons. Four apical plates. A mid-ventral accessory strip in the precingular row.

Length, 45 μ; transdiameter, 32 μ.

Station, 4732.

Murrayella punctata (Cleve).

Steiniella (?) *punctata* Cleve.

Plate 9, Fig. 58.

A small species, variable in size and proportions, biconical in form with median girdle and axis shifted ventrally.

Body elongated, length 1.55 times the dorso-ventral and 1.7 times the transdiameter. Epitheca and hypotheca subequal. Epitheca conical, its altitude 1.8 of its transdiameter, right and left margins straight or concave, base occasionally somewhat flaring, dorsal margin convex, more so than the ventral, apex displaced ventrally, broadly rounded.

Hypotheca resembling the epitheca, but its ventral face is concave, and the ventrally displaced antapex is more or less acute.

Girdle relatively wide in small individuals, and narrower in large ones, furrow deeply impressed with slightly salient margins, forming a descending right spiral displaced its own width. The longitudinal furrow is very long, 0.75 of the total length of the body. It runs from the girdle to the apex, narrowing gradually till at a point half-way to the apex it is continued as a linear channel. Near the middle of the epitheca it is deflected to the right. On the

hypotheca it turns to the right distally and forms a broad channel with high membranous lists on either side.

The post- and precingular plates are normal. There are four apicals and two antapicals. Suture lines are marked by bands, and the plates are finely reticulate with small subequal irregular polygons. The transverse and longitudinal furrows are partially reticulated. An exceedingly variable species.

Length, 65–155 μ; dorso-ventral diameter, 40–73 μ.

Stations, 4691, 4730, 4732.

Murrayella rotundata, sp. nov.

Plate 9, Fig. 55.

A minute spheroidal species without apical or antapical horns.

Body rotund, spheroidal, its length 1.05 times the dorso-ventral diameter. Epitheca less than the hypotheca, its altitude 0.42 of the total length and 0.44 of the dorso-ventral diameter, low dome-shaped, slightly flaring at girdle.

The hypotheca is symmetrical, less rotund than the epitheca, and less flaring at the girdle, almost hemispherical, with a minute antapical elevation a little to the ventral side of the antapical pole.

Girdle horizontal, slightly impressed, with salient ridges, forming a descending right spiral displaced its own width. Longitudinal furrow narrower than the girdle, extending one girdle width on the hypotheca and two on the epitheca.

Length, 45 μ; dorso-ventral diameter, 43 μ.

Station, 4701.

ACANTHODINIUM, gen. nov.

(?) *Cladopyxis* Stein ('83) in part.

Body spheroidal with premedian girdle. Epitheca with apical pore, four apical and eight precingular plates. Hypotheca with two antapical, six postcingular plates, and a longitudinal furrow plate of two moieties. The pre- and postcingular plates and the antapicals usually bear a centrally located spine, which is simple or branched distally. Thecal wall porulate.

Acanthodinium caryophyllum, sp. nov.

Plate 11, Fig. 67.

Similar to *A. spinosum*, but with ends of spines quadripartite with hyaline films connecting the divisions. Spines with one axial pore canal, occasionally with two or three connecting or independent ones at the base. This axial canal branches peripherally in the processes, which are usually four, occasionally two or three. The thecal plates are similar in number and general arrangement to those of *A. spinosum*, and the spines show a similar distribution on the plates and are subject to similar irregularities in distribution. The spines are longer (0.7–0.9 transdiameters at girdle) than in *A. spinosum*, but in other respects the dimensions are nearly the same.

Possibly an older form of *A. spinosum*. Intermediate stages not, however, observed. Transdiameter of midbody, 40 μ; length of spines, 35 μ.

Station, 4722.

Acanthodinium spinosum, sp. nov.

Plate 11, Fig. 66.

Axial length of body (without spines) 1.1–1.2 transdiameters of girdle. Dorso-ventral and transverse diameters equal. Epitheca less than hypotheca. Altitude of epitheca 0.3–0.4 of the axial length from the apex. Transverse furrow very lightly indented, its proximal and distal ends not displaced. Longitudinal furrow short with low lists. Epitheca with small circular area about apical pore. Apical plates without spines. Dorsal and ventral apicals narrow, laterals very wide. Of the eight precingular plates the two midventrals are small, and the remaining six are large, subequal, and bear centrally located spines. The two laterals are often without spines.

In the hypotheca the plates are less regular. The two antapicals are unequal in size and may bear spines. The six postcingulars are also unequal, the left midventral being smaller and the others increasing in size to the right. The longitudinal furrow plate consists of a larger posterior and smaller anterior moiety. Spines have been found on all plates of the hypotheca excepting only the furrow plates and the left midventral postcingular. Spines 0.4–0.6 transdiameters at girdle in length, slightly curved conical, tapering evenly, to a sharp point, with one central pore canal. Suture lines marked by single, rarely doubled, ridges. Thecal wall porulate. Plates usually bordered by a peripheral pore-free band.

Length, 45 μ; diameter at girdle, 40 μ; length of spines 16–25 μ.

Stations, 4707, 4722.

This is the type of *Acanthodinium*.

Phalacroma lenticula, sp. nov.

Plate 12, Fig. 69.

A medium-sized species with lenticular body, very high epitheca, and finely reticulate wall.

Body lens-shaped, much compressed laterally, its transdiameter less than 0.25 of the dorso-ventral, nearly circular in lateral view, the dorso-ventral width of the body exclusive of the fin, 1.06 times the length, the longest antero-posterior axis being slightly oblique (10° antero-dorsally) to the girdle. The epitheca is unusually high, nearly equalling the hypotheca in length. The girdle is narrow, furrow not impressed, with low fins. Left ventral fin with two ribs, the right low, reticulate at the base.

Thecal wall finely reticulate, about 16 mesh on the radius at the girdle, minutely porulate.

Length, 81 μ; dorso-ventral diameter, 86 μ.

Station, 4749.

Phalacroma reticulata, sp. nov.

Plate 12, Fig. 72.

A small species of biconical form, laterally compressed, with very coarse reticulations.

The length is 1.6 times the transdiameter, and 1.25 times the dorso-ventral. The epitheca is a low symmetrical cone, laterally compressed, its altitude 0.48 of its dorso-ventral diameter and 0.57 of its transdiameter. Its sides are straight and the apex is broadly rounded.

The hypotheca is a high cone, its altitude a trifle less than its transdiameter and 0.8 of its dorso-ventral. Its ventral margin is convex in the middle, the dorsal nearly straight and the laterals a little concave. The antapex is rounded.

The girdle is 0.4 of the length from the apex and has low hyaline lists. The left ventral list is high, with a single prominent rib and several secondary ones. It is decurrent posteriorly and is continued around the hypotheca on the right side of the suture to the dorsal girdle, as a low list.

The surface is coarsely reticulate, with 24 polygons on the epithecal valve and 36 on the hypothecal.

Length, 100 μ; transdiameter, 64 μ.

Station, 4740.

Phalacroma striata, sp. nov.

Plate 12, Fig. 73.

A large species resembling *P. cuneus*, but differing in the form of antapex. In *P. cuneus* this is symmetrically contracted to a rounded antapex. In *P. striata* the hypotheca is relatively larger, is broadly rounded at the antapex and more expanded ventrally. The ventral margin is nearly straight, and forms a right angle with the girdle. The left ventral fin follows the outline of the body or even exaggerates the ventral expansion, and reaches the level of the antapex. It is faintly radially striate. Girdle with wide membranous lists.

Thecal wall reticulate, with coarse polygons each with central pore.

Length, 120 μ; dorso-ventral diameter in girdle, 120 μ.

Stations, 4638, 4719.

Phalacroma ultima, sp. nov.

Plate 12, Fig. 68.

A bizarre species of small size with bifurcated antapex and longitudinal furrow displaced to the right.

The length of the body is 1.6 times the greatest dorso-ventral extension, and 4 times the transdiameter (excluding the collars). The epitheca is low, its greatest altitude above the furrow is 0.35 of its dorso-ventral diameter. It is highest in the ventral third and declines rapidly dorsally.

The hypotheca is deeply and broadly bifurcated by a wide arc which reaches the posterior end of the longitudinal furrow. The depth of the bifurcation is but little less than the dorso-ventral diameter of the body in the girdle. As a result of the bifurcation there are two slender tapering acute horns, a shorter ventral and longer dorsal. Their length is about 0.75 of the distance between their tips.

The girdle is wide, with flaring sub-horizontal lists. The longitudinal furrow is turned abruptly to the right and runs on the right face of the organism to the dorsal side of base of the ventral horn. The suture between the valves follows this course and then turns abruptly toward the ventral margin of the horn.

There is a low ridge on the right side of the furrow which continues as a short spine beyond the posterior margin of the body.

Length, 60 μ; dorso-ventral diameter, 38 μ.

Station, 4711.

Dinophysis triacantha, sp. nov.

Plate 12, Fig. 74.

Related to *D. schütti* Murr. et Whitt. and *D. uracantha* Stein. Resembles *D. uracantha* in having marginal ribs to the postero-dorsal spine. Differs from both of these species in the presence of a third spine in the ventral fin, located at its dorso-posterior margin and formed as in the case of the postero-dorsal spine by marginal thickenings.

Body broadly ovate in lateral view, anterior collar unevenly ribbed, ventral fin feebly reticulated. Thecal wall with fine irregular reticulations, a few of which contain pores. The three spines subequal, in length about 0.5 of the dorso-ventral diameter of the body.

Length of body without spines or collar, 50 μ; greatest dorso-ventral diameter, 50 μ; spines, 20–25 μ.

Station, 4722.

Amphisolenia asymmetrica, sp. nov.

Plate 13, Fig. 76.

An elongated species resembling *A. dolichocephalica*. Total length nearly twenty-five times that of the neck and nearly fifty times the dorso-ventral diameter of the midbody. Head long, narrow, oblique, its long axis slightly exceeding the neck in length, with low spreading sparingly ribbed lists. Antapical stem curved ventrally and distally deflected abruptly to the right, bearing a short spine in the left face at the point of deflection and three equidistant terminal spinules on the slightly swollen end. Walls thickened distally along sutures which do not follow the median plane of symmetry through the apparently twisted antapex but divide it into two asymmetrical valves, the right with two terminal spinules and the left with one terminal and the lateral.

Nucleus elongated, chromatōphores few, large, ellipsoidal.

Length, 1200 μ; dorso-ventral diameter of the midbody 60 μ; length of head, 190 μ.

Station, 4732.

Amphisolenia bispinosa, sp. nov.

Plate 14, Fig. 85.

A moderately large species of robust proportions, midbody but little expanded and tapering very gradually into the antapical stem, which is slightly curved ventrally and bears two very long attenuate spines, one upon each side. The antapex is porulate, and several sinuous ridge-like markings are found on the short neck. The head is elongated, oblique, with spreading lists with few ribs.

Nucleus much elongated. Chromatophores numerous, ellipsoidal.

Length, 670 μ; dorso-ventral diameter of midbody, 20 μ.

Station, 4605.

Amphisolenia brevicauda, sp. nov.

Plate 13, Fig. 79.

A very small species with elongated midbody and very short, straight, simple antapical.

The head is oblique, elongated, its length 2.5 times its dorso-ventral thickness. The neck is long and slender, its length 0.25 of the total length. The midbody is greatly elongated, slightly enlarged posteriorly, its length 0.5 of the total length, contracting abruptly to a short antapical extension whose length is less than that of the neck. The antapex is acute, without spines or modifications.

Length, 200 μ; transdiameter of midbody, 12 μ.

Station, 4740.

Amphisolenia clavipes, sp. nov.

Plate 14, Fig. 90.

A small but robustly proportioned species with small capitate head, long neck, tapering fusiform midbody not sharply delimited posteriorly. The antapex is bent abruptly to the right for a distance about equalling the greatest transdiameter of the midbody and terminates in a slight knob-like expansion with a dorsal and a ventral spinule.

Nucleus much elongated, chromatophores elongated, cylindrical.

Length, 235 μ; dorso-ventral diameter of midbody, 13 μ.

Station, 4736.

Amphisolenia curvata, sp. nov.

Plate 14, Fig. 87.

A stout species of medium size, with cushion-shaped head, fusiform body, and an antapical stem ventrally curved throughout, without terminal expansion.

A single small terminal spinule occurred on the left valve of individual drawn. Transverse lists low, spreading with few stout ribs, one of which passes down upon the side of the neck. The antapex is porulate and bears a few irregular reticulations on the thecal wall.

Nucleus small, broadly ellipsoidal. Chromatophores numerous, spheroidal.

Length, 460 μ; dorso-ventral diameter of midbody, 35 μ.

Station, 4605.

Amphisolenia dolichocephalica, sp. nov.

Plate 13, Fig. 82.

A large species with long very slender body with slight dorsal convexity. Head oblique, greatly elongated, its length nearly seven times its transverse and ten times its dorso-ventral diameter. Lists nearly horizontal, with numerous fine ribs. Neck about as long as the head, midbody tapering, fusiform. Antapex curved somewhat ventrally and to the right, with subcapitate termination bearing two straight spinules at the suture and decurrent hyaline ridges which pass quickly from the knob-like end to the slender cylindrical stem.

Nucleus greatly elongated.

Length, 1050 μ; dorso-ventral diameter of midbody, 22 μ; length of head, 82 μ.

Station, 4728.

Amphisolenia extensa, sp. nov.

Plate 13, Fig. 78.

A very large species with flattened very oblique head, relatively short neck, stout fusiform midbody and an enormously elongated antapical stem which is six times the length of the rest of the organism. The head is flattened ellipsoidal, with low spreading lightly ribbed transverse lists, a ribbed furrow, and coarsely ribbed longitudinal lists. The antapical stem is slightly convex dorsally and terminates in a slightly swollen subtruncate antapex without spines.

Nucleus elongated, chromatophores numerous, subspheroidal.

Length, 1380 μ; dorso-ventral diameter, 25 μ.

Station, 4699.

Amphisolenia laticincta, sp. nov.

Plate 13, Fig. 80.

A minute species with straight fusiform body. Head obliquely rounded, transverse furrow very wide, equalling the long axis of the head in width. Transverse lists low, spreading, with few faint ribs. Neck short, slightly exceeding the dorso-ventral diameter of the midbody in length. Midbody fusiform, forming nearly half of the total length. Antapical stem straight, with a single terminal spinule.

Nucleus elongated, chromatophores small, irregular.

Length, 112 μ; dorso-ventral diameter of midbody 9 μ; width of transverse furrow, 6 μ.

Station, 4740.

Amphisolenia lemmermanni, sp. nov.

Plate 14, Figs. 88, 89.

A species of medium size with broadly fusiform midbody, elongated, straight antapical stem with terminal expansion deflected to the right. The head is oblique, the neck about 1.4 times the dorso-ventral diameter of the midbody in length, and the terminal expansion of the antapex with three acute spines, one on the left side a short distance above the end at the point of deflection of the spreading antapex which is carried out on its dorsal and ventral angles in the other two spines. A slight knob-like expansion at the end of the straight section is connected by lists with the terminal spinules.

Length, 565 μ; dorso-ventral diameter of the midbody, 40 μ.

Station, 4730.

Amphisolenia palaeotheroides, sp. nov.

Plate 14, Fig. 84.

Body stout, its length 20–36 times the greatest dorso-ventral diameter, elongated fusiform with central swelling scarcely differentiated. Flagellar pore removed from the apex 0.12 of the total length. Antapex twisted slightly, terminating in an oblique asymmetrical enlargement with three large, stout, terminal spines. A similar stout spine at the beginning of the obliquity a short distance above the antapex. Collars with few ribs, transverse furrow ribbed and pornlate.

Length, 426–605 μ; dorso-ventral diameter of body, 12–24 μ.

Station, 4732.

Amphisolenia projecta, sp. nov.

Plate 13, Fig. 77.

A small species of the *A. thrinax* group with bifurcated antapex whose ventral limb resembles that of *A. bifurcata* while the dorsal one is a knob-like prominence without spinules or lateral asymmetry. Body elongated with fusiform midbody. Total length 17 times the dorso-ventral diameter. Flagellar pore to apex 0.16 of the total length. Bifurcation to antapex 0.2 of the total length. Ventral limb of antapex fusiform, with four spinules, one lateral, and three terminal, limb deflected to the right at level of the lateral spinule. Dorsal limb equal to dorso-ventral diameter of midbody in length, clavate, its length twice its width.

Length, 185 μ; dorso-ventral diameter, 11 μ.

Station, 4701.

Amphisolenia quadrispina, sp. nov.

Plate 14, Fig. 86.

Body very long and slender, its length about 45 times the greatest dorso-ventral diameter, attenuate, fusiform, expanding posteriorly to a knob-like termination with four equidistant short incurved terminal spinules. Body constricted immediately anterior to the knob. Midbody not sharply delimited, about one third of the total length in length. Length of neck (girdle to flagellar pore) 0.13 of the total length, or four to five dorso-ventral diameters of the head without lists. Head capitate, transverse lists spreading, subhorizontal with few fine ribs, width of lists equals the transdiameter of the head. Terminal knob porulate.

Nucleus elongated, many small spheroidal chromatophores.

Length, 635–689 μ; dorso-ventral diameter of midbody, 14–17 μ.

Stations, 4613, 4722.

Amphisolenia quinquecauda, sp. nov.

Plate 13, Fig. 75.

This is a large species resembling *A. thrinax* but having five instead of three antapical ends. The neck and midbody form the apical third of the body, and the branches begin with the antapical third. The neck is short, but little longer than the dorso-ventral diameter of the midbody, which is stout, fusiform, its dorso-ventral diameter but slightly exceeding its transverse diameter.

The head is elongated, oblique, with spreading transverse lists heavily ribbed with about 20 ribs. The axis in the posterior third bends ventrally in a double curve and ends in a triangular antapex with short spinules on the angles. There is a dorsal spine a short distance from the antapex. The four branches are arranged in one plane in a single dorsal series and are all without enlargements, slightly curved, with the convex side dorsal. The first branch has an end similar to that of the axis, but the three slightly shorter ones of the middle group have but two small terminal spinules.

Nucleus elongated. Chromatophores small, elongated, very numerous.

Length, 835 μ; dorso-ventral diameter of midbody, 42 μ; length of first dorsal process about 300 μ.

Station, 4739.

Amphisolenia rectangulata, sp. nov.

Plate 14, Fig. 83.

A large species with short fusiform midbody, elongated oblique head, and much elongated antapical stem with very slight ventral curvature. The antapex terminates with very slight enlargement in rectangular form with the major axis dorso-ventral, and an acute spinule on each corner.

Nucleus much elongated; chromatophores spheroidal, numerous.

Differs from *A. quadrispina* in the more broadly fusiform midbody and in the form of the antapex, having no spheroidal enlargement.

Length, 735 μ; dorso-ventral diameter of midbody, 24 μ.

Station, 4740.

Amphisolenia schroederi, sp. nov.

Plate 13, Fig. 81.

A medium-sized species with capitate head, elongated fusiform midbody, and antapex with two spinules.

The body is elongated, its length 25 times the dorso-ventral diameter. The head is small, spheroidal, its diameter less than that of the midbody. The neck is about 0.16 of the total length and the midbody is not differentiated. The antapex is not enlarged, is truncate, and deflected to the right. It bears on the angles two stout terminal spines both of which are on the right valve.

This species differs from *A. bispinosa* in the location of the terminal spines and in the form of the head.

Length, 510 μ; dorso-ventral diameter of the midbody, 20 μ.

Station, 4737.

TRIPOSOLENIA, Kofoid.[1]

Dinophysidae with equal or unequal valves. With three subequal processes from a laterally compressed central midbody, one anterior and two posterior. The anterior process consists of the head, neck, protuberant cytopharyngeal region, and a short process from the midbody. The posterior processes are two symmetrically placed curved antapical horns, respectively dorsal and ventral in origin, with or without marginal tubercles or terminal spinules. The head and neck resemble those of *Amphisolenia*. The essential difference between *Amphisolenia* and *Triposolenia* lies in the presence in the latter of balanced antapicals arising from a midbody containing the greater mass of protoplasm and the nucleus. In all known forms of *Amphisolenia* the midbody is fusiform and bears no dorsal horn, the dorsal horn, if present, arising from the antapical process.

The thecal wall is structureless, pitted, or rarely locally reticulate.

The nucleus is located in the midbody. Chromatophores lacking (?) or of pale greenish-yellow color.

Sparingly distributed in warm temperate and tropical waters, but rarely taken at the surface.

Triposolenia longicornis, sp. nov.

Plate 17, Fig. 101.

A very large species with long process and long antapical horns, small triangular midbody, and flattened head.

[1] Kofoid, C. A. Dinoflagellata of San Diego Region II. On Triposolenia, a new genus of the Dinophysidae. Univ. of Calif. Pubs. Zoöl., 3, p. 99–133, plates 15–19. 1906.

The midbody is laterally compressed, triangular in lateral view with the anterior margins subequal and both concave. The postmargin is but slightly convex. The anterior process is long, its length equalling that of an anterior margin. The cytopharyngeal margin is expanded ventrally to twice the dorso-ventral diameter of the neck, which is slender, its length being nearly one and one half times that of the process. It is curved dorsally in a regular arc, which continues the curvature of the dorso-ventral margin of the midbody. The head is flattened and the transverse furrow is slightly constricted.

The antapicals arise from the postero-lateral angle of the midbody and spread latero-posteriorly in a broad curve. The tips are somewhat incurved, but there is no sigmoid flexure as in *T. fatula*. The greatest distance between the antapicals is 0.63, and that between the tips 0.5 (of the total length). The antapicals are truncate in dorsal or ventral view, with short lateral terminal spinules. In lateral view they are somewhat rounded. Both horns are deflected to the left distally, the dorsal somewhat more than the ventral.

The lists are heavily and sparingly ribbed and the thecal wall shows no structural differentiation.

Length to postmargin of midbody, 125 μ; to tip of ventral antapical, 275 μ.

Stations, 4385, 4711.

Its long process and horn are evidently adaptive to the higher temperatures of its habitat.

Triposolenia fatula, sp. nov.

Plate 17, Fig. 102.

A large species resembling *T. ambulatrix* with less asymmetry of the spreading antapicals and a constricted region in the anterior part of the neck.

The midbody is low triangular in lateral view with nearly straight margins, the posterior longer, and the antero-ventral shorter than the antero-dorsal. The anterior process is long, its length exceeding the altitude of the midbody. The neck is very long and slender and its distal fifth is reduced in dorso-ventral diameter and bent dorsally to a slight extent. Its length is about 0.2 of the total length. The head is spheroidal and relatively small.

The antapicals are very long, their length being 4.5 times the altitude of the midbody. They are slightly asymmetrical, the dorsal is slender, does not converge or show a sigmoid flexure distally, as does the ventral. The distance between the tips is five times the altitude of the midbody. Distally the dorsal antapical bends to the left, and the ventral one only slightly at the very end. The tips are truncate and minutely spinulate.

The thecal wall is hyaline, structureless, and the collars and lists are heavily but sparingly ribbed.

Length to postmargin of midbody, 90 μ; to tip of ventral antapical, 190 μ.

Station, 4587.

Triposolenia ambulatrix, sp. nov.

Plate 4, Fig. 24.

A medium-sized species of the *T. bicornis* type with both antapical horns deflected dorsally, especially the dorsal one.

The midbody is laterally compressed, subtriangular in lateral view with anterior process and antapicals arising from the angles as in *T. bicornis*. Its sides are all convex and the anterior process arises abruptly from somewhat squarish shoulders. The head is spheroidal, and the neck long, slender, and convex ventrally. There is a large ventral protuberance about the flagellar pore.

The ventral antapical is abruptly deflected postero-dorsally and forms a slight sigmoid curve which is less pronounced distally. Its tip is acute and it is deflected to the *right* distally. The dorsal antapical is not bent to form a balanced horn, in reverse, as in *T. bicornis*, but is thrown dorso-posteriorly with a slight anterior convexity. Its tip is truncate and bears two minute spinules. It is deflected to the *left* distally. There are a few distally located tubercles on the dorsal and ventral margins of the antapicals.

Length to postmargin of midbody, 95 μ; to tip of ventral antapical, 165 μ.

Station, 4711.

Histioneis carinata, sp. nov.

Plate 16, Fig. 98.

Somewhat resembling *H. biremis* Stein as figured by Murray and Whitting[1] in its bird-shaped body, and in the absence of a postero-dorsal prolongation. The anterior collar is less abundantly ribbed, and both it and the posterior one are asymmetrical, being lower at the right end. There is no fin dorsal to the posterior rib. The areoles on the midbody are more numerous, being 11 by 20 to 8 by 15 in *H. biremis*. There is no ventro-marginal rib in the posterior wing.

Length, 90 μ; dorso-ventral diameter of midbody, 50 μ.

Station, 4724.

Histioneis garretti, sp. nov.

Plate 16, Fig. 97.

A small species resembling *H. para* Murr. et Whitt. but differing from it in the presence of a fin on the dorsal side of the posterior rib. There are reticulations in the basal part of the anterior collar, and along the dorsal ribs of the posterior collar. The ventral and posterior fins are also more or less reticulate. Both collars closed ventrally and dorsally.

Length, 63 μ; dorso-ventral diameter, 38 μ.

Station, 4732.

[1] New Peridiniaceae from the Atlantic. Trans. Linn. Soc. Lond. Bot., 32, Plate 32, Fig. 6.

Histioneis josephinae, sp. nov.

Plate 15, Fig. 91.

A large species with deeply concave midbody and broad, subcylindrical, posterior collar as in *H. helenae*. This species is especially marked by the enormous development of the various wings and by the presence in their peripheral portions of arborescent thickenings which resemble a coral necklace in form. In addition to an enormously developed posterior dorso-ventral wing there is also present a pair of transverse wings arising from the posterior rib, and a great accessory lateral on the left side, the latter as well as the ventral wing being provided with an excessively hyaline outer segment. Each of these wings bears one or several coral-like thickenings at the termination of ribs or in peripheral regions. The most striking development of organs of flotation among the Dinoflagellidia.

Length, 115 μ; dorso-ventral diameter, including wings, 80 μ.

Station, 4699.

Histioneis longicollis, sp. nov.

Plate 16, Fig. 100.

A small species resembling immature stages of *H. cymbalaria* but differs from it in having a more rotund body, a postero-ventral fin deflected ventrally from the axis and without ventral marginal rib. The posterior collar bears a hyaline list on its anterior margin outside of the rib. Both collars are closed both dorsally and ventrally by hyaline membranes. The body wall is not pitted or reticulated.

Length, 70 μ; dorso-ventral diameter of body, 24 μ.

Station, 4711.

Histioneis navicula, sp. nov.

Plate 16, Fig. 96.

A medium-sized species with boat-shaped body resembling that of *H. cymbalaria* but longer and more slender. The posterior collar resembles that of *H. biremis*, but both it and the anterior are complete both dorsally and ventrally, there being no gap in the suture line. The anterior collar is asymmetrical, being shorter along the right margin. This collar is somewhat reticulated and ribbed. The ventral fin has a single ventral and one posterior rib, the latter branching at the tip. Phaeosomes in the anterior chamber.

Length, 86 μ; dorso-ventral axis of body, 62 μ.

Station, 4734.

Histioneis paulseni, sp. nov.

Plate 15, Fig. 94.

A small species related to *H. remora*. It differs from it in having the body more elongated in the dorso-ventral direction, a wider and relatively shorter

postero-ventral fin, in the absence of reticulations on the fins, and in the presence of a hyaline border on the anterior margin of the posterior collar. Both dorsal and ventral collar clefts in both collars are closed by delicate hyaline membranes.

Length, 64 μ ; dorso-ventral diameter of body, 33 μ.

Station, 4711.

Histioneis pulchra, sp. nov.

Plate 16, Fig. 99.

A medium-sized species of the general form of *H. mitchellana* but differing from it in the character of the reticulations of the wings and collars. In *H. pulchra* the reticulations are coarse, irregular, and more or less incomplete. They are found on the anterior parts of the two collars, on the posterior part of the ventral, and on the posterior wings. In *H. mitchellana* the reticulations are fine, delicate, and more or less regular.

Length, 135 μ; dorso-ventral diameter, 60 μ.

Station, 4730, 4734, 4742.

Histioneis reticulata, sp. nov.

Plate 15, Fig. 93.

A small species resembling *H. crateriformis* Stein but differing from it in the much lower anterior collar, a higher, more recurved anterior process from the body, in the presence of a subregular polygonal reticulum on parts of the posterior collar and on the ventral fins, and in its straight posterior rib.

Both ventral fins are relatively low. The left has two ribs, both of which are straight. The middorsal and midventral clefts of the posterior collar are both closed by membranes, the former with five equidistant transverse ribs running across the closing membrane.

Length, 115 μ ; dorso-ventral diameter, 85 μ.

Stations, 4699.

Ornithocercus carolinae, sp. nov.

Plate 15, Fig. 92.

A medium-sized species resembling *O. magnificus* but differing from it in the following particulars: the posterior wing has 12–14, rarely 9–15, light ribs of uniform size evenly distributed without prominent midribs to the marginal and median projections. These ribs are more slender and more numerous than those in *O. magnificus*. The anterior collar has numerous (twenty or more) primary ribs, with intercalated secondary and tertiary ones. The right and left ventral wings are in old (?) individuals reticulated. Reticulations may also be found in the middorsal region of the posterior collar, at the base of the anterior one, and on the dorsal margin of the posterior wing.

Length, 100 μ; dorso-ventral diameter, 65 μ.

Stations, 4719, 4721, 4722, 4724, 4740.

Ornithocercus heteroporus, sp. nov.

Plate 12, Fig. 70.

A minute species with slightly oblique axis, relatively few ribs in the collar, posterior wing confined to the ventral side of the midbody, with marginal ribs. Pores heterotypical.

Midbody rotund, laterally compressed, its length 1.16 times the dorso-ventral and 1.3 times the transverse diameter. Anterior collar flaring with few ribs, reticulated basally. Posterior collar with 8 ribs, a row of coarse reticulations at its base and along the base of the right ventral wing (obsolete in individual figured). Left ventral reticulate at base. Posterior wing confined to ventral side with marginal ribs and peripheral seam. Thecal wall porulate with evenly distributed pores, one in 6 or 8 darker than the others.

Length, 50 μ; dorso-ventral diameter, including fin, 37 μ.

Station, 4699.

Ornithocercus serratus, sp. nov.

Plate 15, Fig. 93.

A large species with rounded posterior wing with 4–5 equidistant rounded or acute apices.

This species differs from all others in the large number and the regularity of the marginal prominences of the posterior wing, each of which is the termination of a single rib. There is as a rule no marginal connecting rib as often in *O. magnificus*, *steini*, and *quadratus*. The dorsal margin of the posterior wing is more rounded, not angular or squarish as in other species. The ribs are also more regularly spaced, freer from branching and other irregularities, and the posterior wing has less intercostal reticulation. Terminal reticular brushes appear on some individuals at the ends of the ribs.

Length, 110–145 μ; dorso-ventral diameter, 95–130 μ.

Stations, 4613, 4742.

Amphilothus quincuncialis, sp. nov.

Plate 1, Fig. 10.

A minute species of ellipsoidal form, median girdle, with skeletal elements with quincuncial arrangement in the hypotheca.

Body broadly ellipsoidal, its length 1.6 times the transverse diameter. Epitheca and hypotheca subequal. Epitheca a low cone with very constricted blunt apex, its altitude 0.8 of its transdiameter.

Hypotheca a low dome with very broadly rounded antapex, its altitude 0.8 times its transdiameter.

Girdle 0.1 of the total length in width, nearly median in position, deeply impressed, without lists, horizontal, without displacement. Longitudinal furrow straight, a wide shallow furrow, 0.8 of the length of the body in length, equally extended on the two sides of the girdle.

Skeletal elements superficial, diamond-shaped in hypotheca, 5–6 rows, with primary nodal tubercles and smaller internodal beads and openings in each area, with irregular mesh between pores and margins. In the epitheca there are about 16 subregular meridional ridges with pores between.

Length, 33 μ; diameter, 20 μ.

Anchorage at Panama, surface.

EXPLANATION OF PLATES.

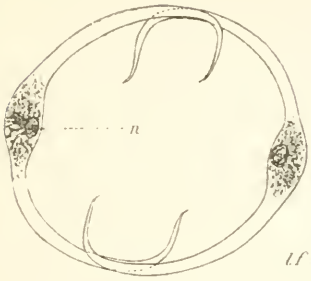
All figures have been drawn with camera lucida. They have been drawn in ink for reproduction by Mr. A. B. Streedain from pencil sketches made by Miss E. J. Rigden, with few exceptions, those designated in the explanations as drawn from life being made by the author.

ABBREVIATIONS.

a. c., anterior collar.
a. l. f., accessory lateral fin.
ant., antapex.
ap. p., apical pore.
arb., arborescent thickening.
a. v., anterior valve.
car., carina.
D., dorsal side.
d. ant., dorsal antapical horn.
f. p., flagellar pore.
h., head.
L., left side.
l., lens.
l. f., longitudinal furrow.
l. i. p., left intercalary plate.
l. v. f., left ventral fin.
mb., midbody.
mel., melanosome.
n., nucleus.
nk., neck.
o. s., outer segment.
p., pore.
p. c., posterior collar.
p. can., pore canals.
p. f., posterior fin.
ph., phaeosomes.
p. v., posterior valve.
R., right side.
r. l. f., right lateral fin.
r. v. f., right ventral fin.
s., suture.
sk. el., skeleton elements.
sp., spine.
th. w., thickened wall.
tr. f., transverse furrow.
v., ventral side.
v. a., ventral area.
v. ant., ventral anterior horn.
v. f., ventral fin.
v. p., ventral pore.
v. pl., ventral plate.

PLATE 1.

Fig. 1. *Prorocentrum curvatum*, sp. nov., lateral view. × 565. From life.
Fig. 2. The same, anterior face. × 565.
Fig. 3. *Pyrocystis fusiformis*, forma *biconica*, f. nov. × 100.
Fig. 4. *Pyrocystis acuta*, sp. nov. × 62.
Fig. 5. *Pyrocystis robusta*, sp. nov. × 320.
Fig. 6. *Pyrocystis semicircularis* (Schröder), lateral view of yoked pair. × 100.
Fig. 7. *Pouchetia panamensis*, sp. nov., ventral view. × 895. From life.
Fig. 8. *Ptychodiscus carinatus*, sp. nov., ventral view. × 450. From life.
Fig. 9. Lateral view of the same. × 450.
Fig. 10. *Amphilothus quincuncialis*, sp. nov. Oblique view of right face. × 895. From life.



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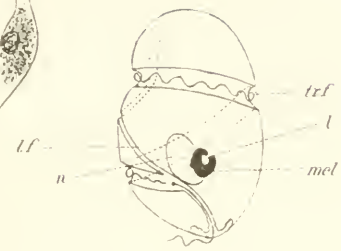

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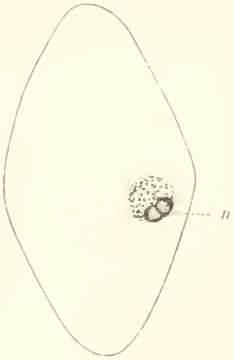

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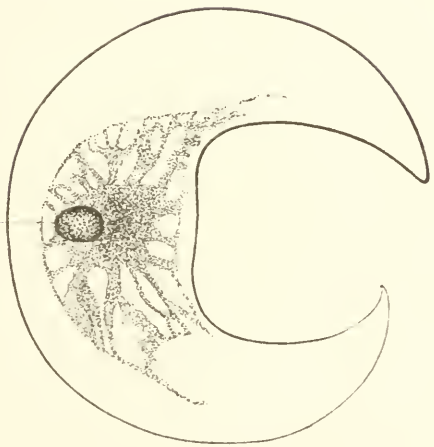

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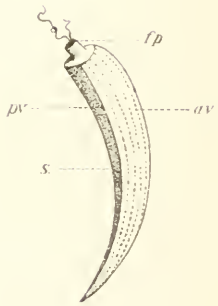

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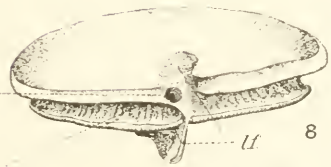

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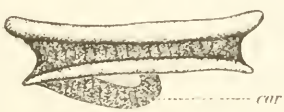

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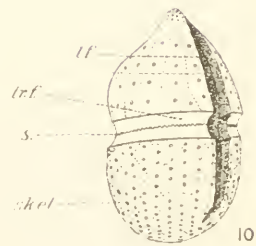

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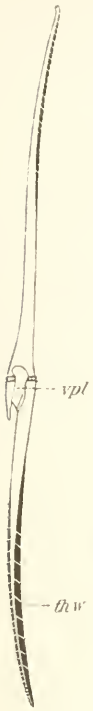
A.K. ... A.B. ...

PLATE 2.

Fig. 11. *Podolampas reticulata*, sp. nov., ventral face. × 935.
Fig. 12. *Ceratium pennatum*, sp. nov., forma *propria*, f. nov., ventral face. × 100.
Fig. 13. *Ceratium pennatum* forma *inflata*, f. nov., ventral face. × 100.
Fig. 14. *Ceratium pennatum* forma *falcata*, f. nov., ventral face. × 100.
Fig. 15. *Steiniella inflata*, sp. nov., ventral face. × 450.
Fig. 16. *Ceratium ehrenbergi*, sp. nov., ventral face. × 450.



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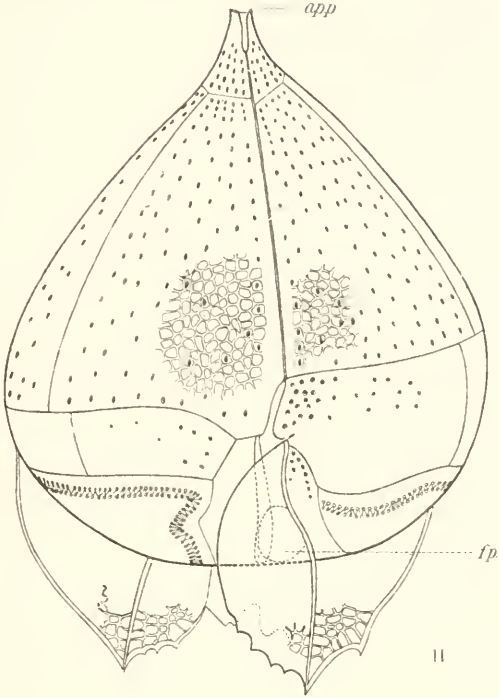

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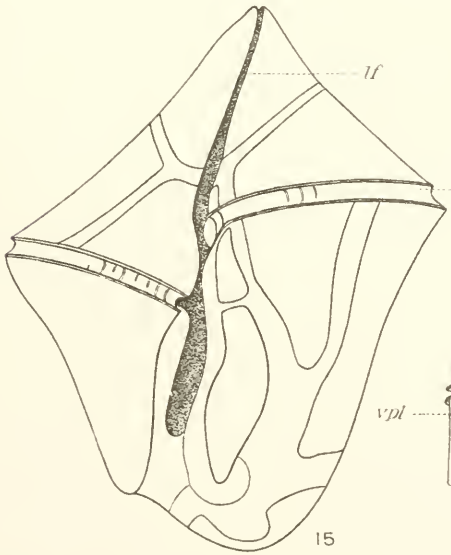

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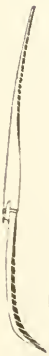

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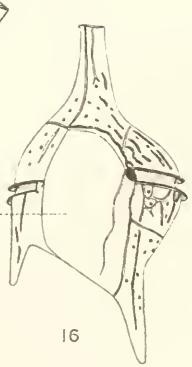

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PLATE 3.

Fig. 17. *Ceratium lanceolatum*, sp. nov., ventral view. × 935.
Fig. 18. *Ceratium schröteri* Schröder, view of dextral face. × 315.
Fig. 19. Ventral view of the same. × 315.
Fig. 20. *Ceratium tricarinatum*, sp. nov., dorsal view. × 210.
Fig. 21. *Ceratium pacificum* Schröder, dorsal view. × 285.
Fig. 22. *Ceratium bigelowi*, sp. nov., dorsal view. × 100.
Fig. 23. *Ceratium scapiforme*, sp. nov., dorsal view. × 205.

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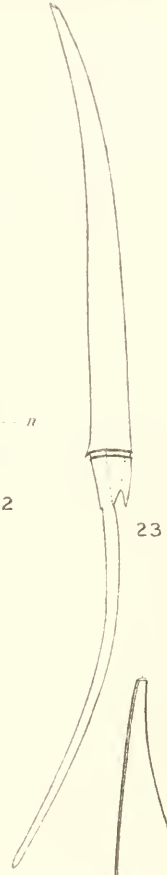
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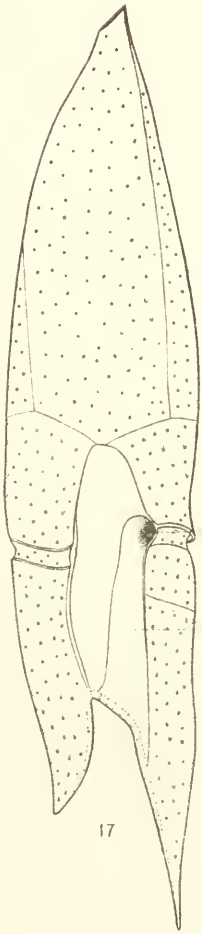
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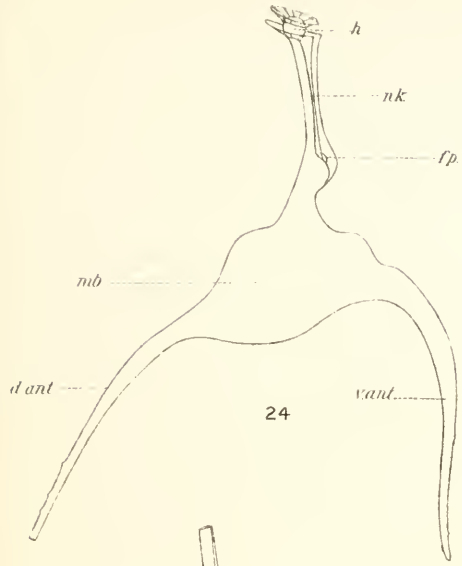
PLATE 4.

Fig. 24. *Triposolenia ambulatrix*, sp. nov., dextral face. × 450.
Fig. 25. *Ceratium dilatata* (Karsten), ventral face. × 450.
Fig. 26. *Ceratium axiale*, sp. nov., ventral face. × 450.
Fig. 27. *Ceratium claviger*, sp. nov., ventral face. × 285. From life.



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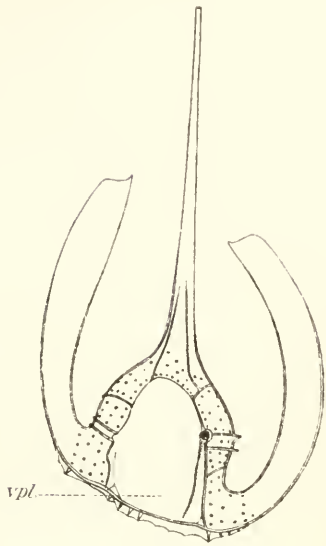

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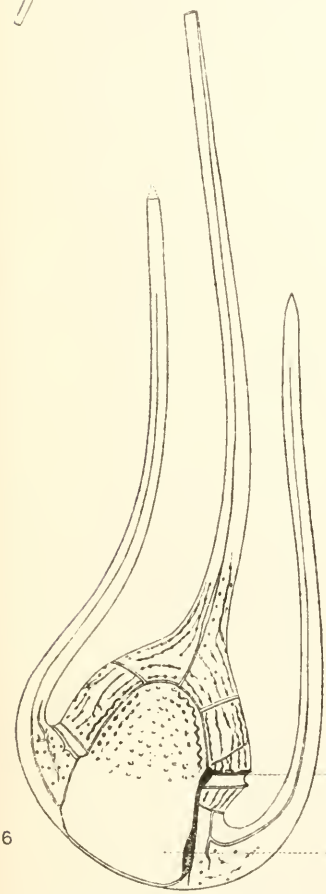

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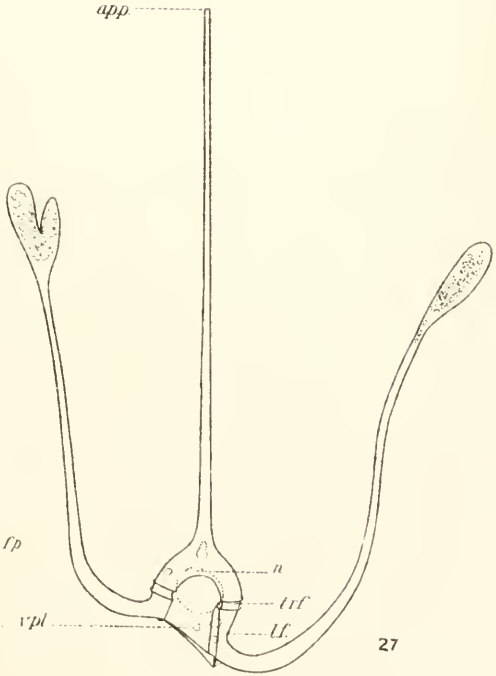

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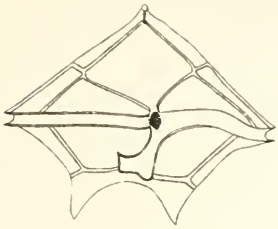
PLATE 5.

Fig. 28. *Peridinium grande*, sp. nov., dorsal face. × 450.
Fig. 29. *Peridinium murrayi*, sp. nov., ventral face. × 295. From life.
Fig. 30. *Peridinium fatulipes*, sp. nov., ventral face. × 565.
Fig. 31. *Peridinium latissimum*, sp. nov., ventral face. × 295. From life.
Fig. 32. Same, diagrammatic apical view. × 295.
Fig. 33. *Peridinium longispinum*, sp. nov., dorsal face. × 450.
Fig. 34. *Peridinium tenuissimum*, sp. nov., ventral face. × 450.



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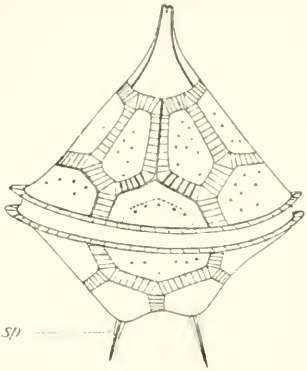

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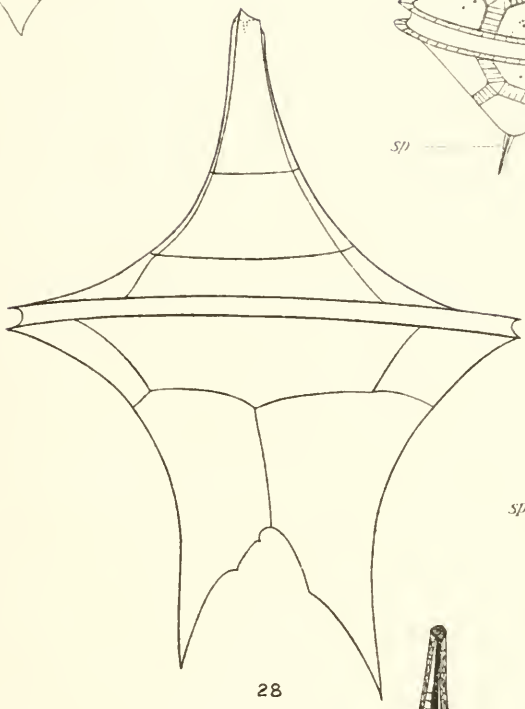

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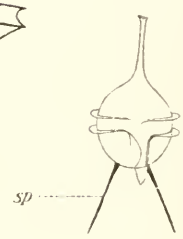

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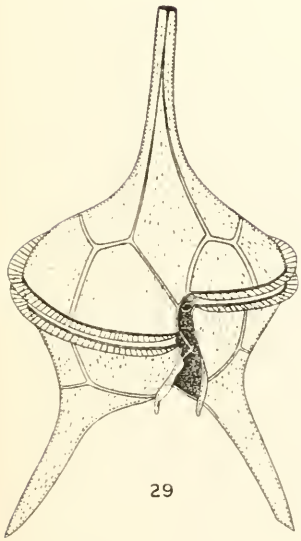

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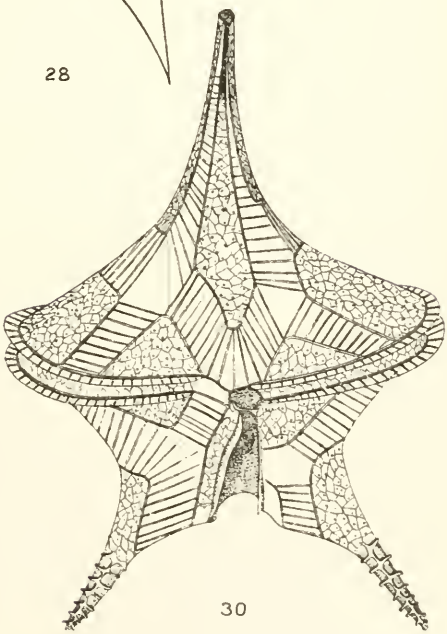

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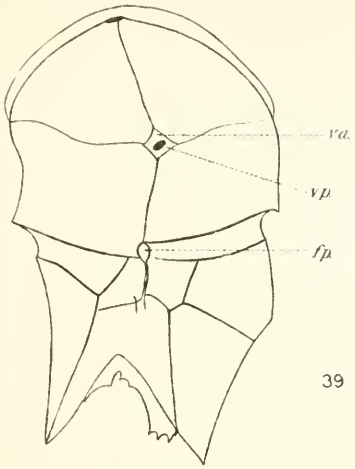
PLATE 6.

Fig. 35. *Heterodinium agassizi*, sp. nov., ventral face. × 450.
Fig. 36. *Heterodinium expansum*, sp. nov., ventral face. × 565
Fig. 37. *Heterodinium gesticulatum*, sp. nov., forma *typica*, f. nov., ventral face. × 440.
Fig. 38. *Heterodinium gesticulatum*, sp. nov., forma *extrema*, f. nov., ventral face. × 450.
Fig. 39. *Heterodinium gesticulatum*, sp. nov., forma *mediocris*, f. nov., ventral face. × 450.
Fig. 40. *Heterodinium gesticulatum*, sp. nov., forma *deformata*, f. nov., dorsal face. × 450.



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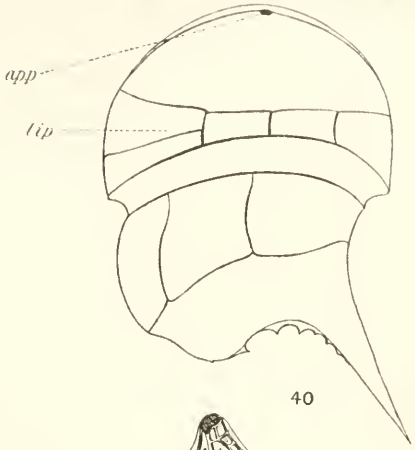

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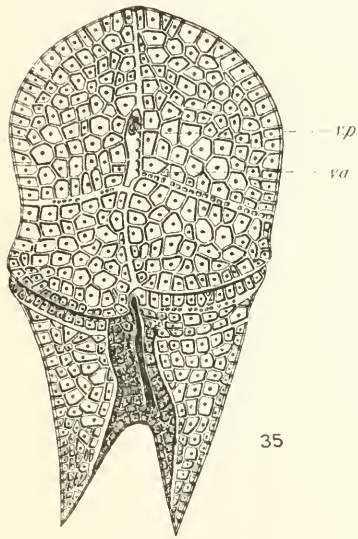

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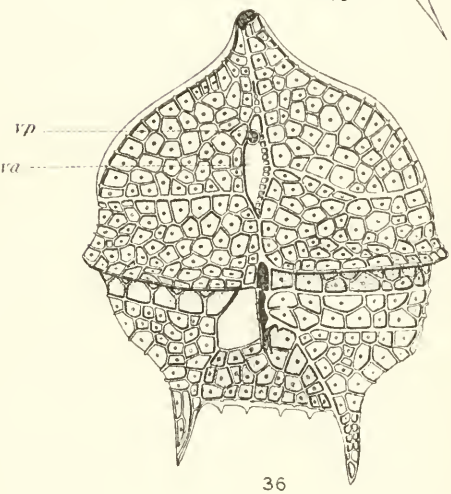

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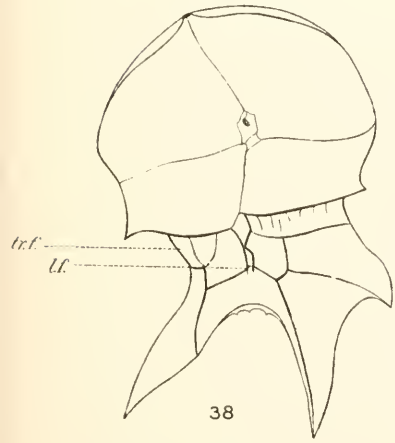

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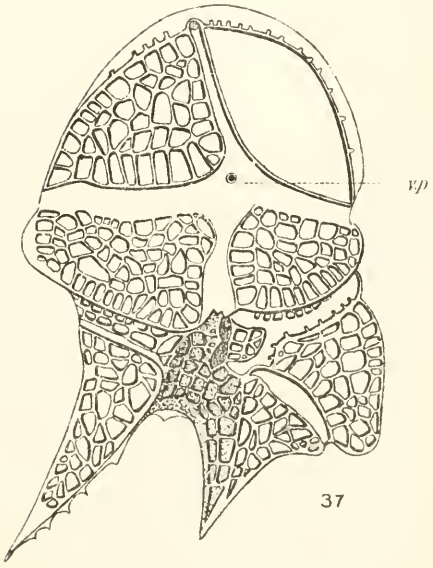

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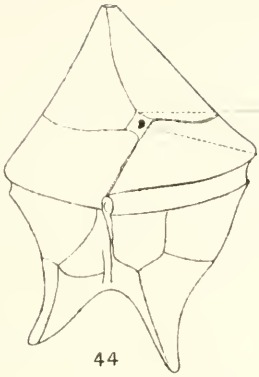
PLATE 7.

Fig. 41. *Heterodinium praetextum*, sp. nov., dorsal face. × 405.
Fig. 42. *Heterodinium hindmarchi* forma *maculata*, f. nov., ventral face. × 405.
Fig. 43. *Heterodinium calvum*, sp. nov., ventral face. × 405.
Fig. 44. *Heterodinium longum*, sp. nov., ventral face. × 405.
Fig. 45. *Heterodinium fides*, sp. nov., dorsal face. × 405.
Fig. 46. *Heterodinium laticinctum*, sp. nov., view of right side. × 405.



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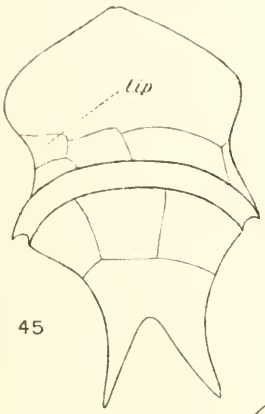

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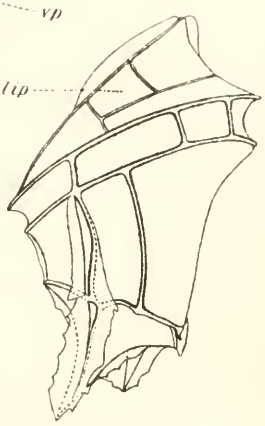

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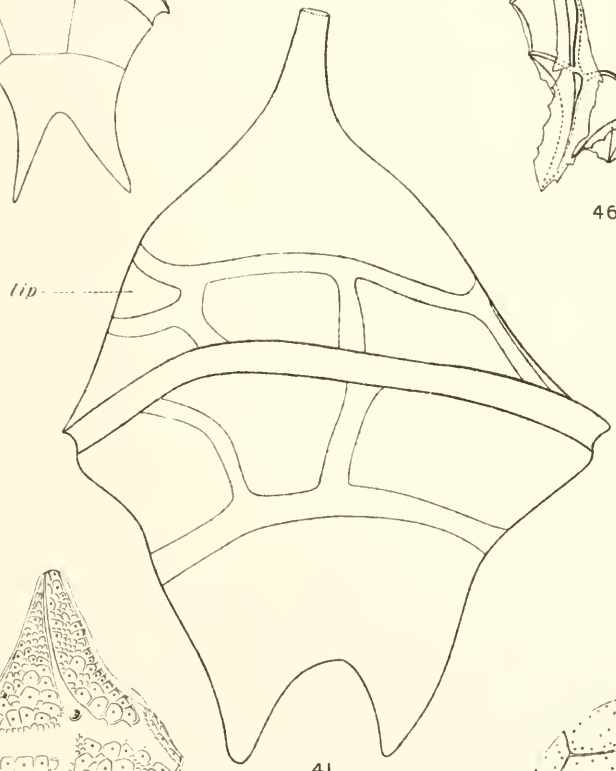

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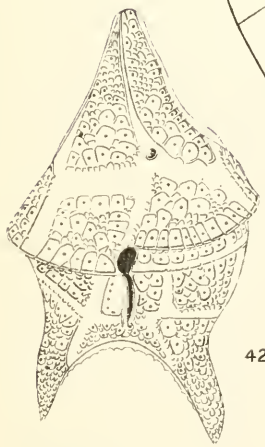

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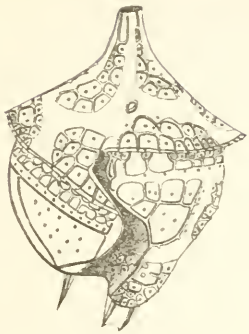
PLATE 8.

Fig. 47. *Heterodinium fenestratum*, sp. nov., ventral face. × 840.
Fig. 48. *Heterodinium curvatum*, sp. nov., ventral face. × 840.
Fig. 49. *Heterodinium superbum*, sp. nov., ventral face. × 840.
Fig. 50. *Heterodinium obesum*, sp. nov., ventral face. × 840.
Fig. 51. *Heterodinium globosum*, sp. nov., ventral face. × 840.



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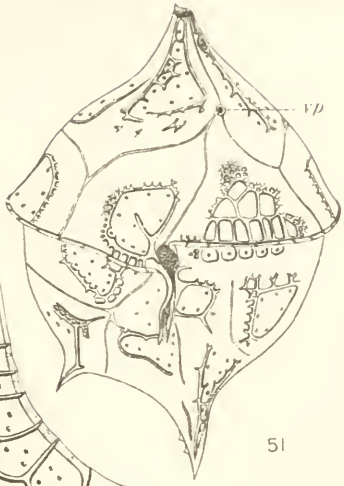

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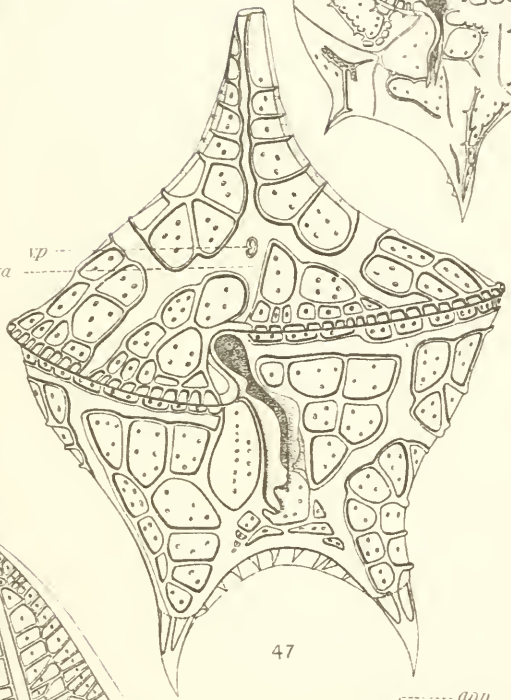

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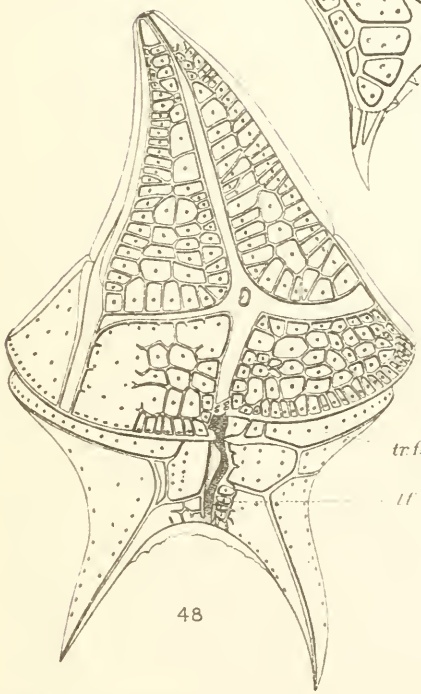

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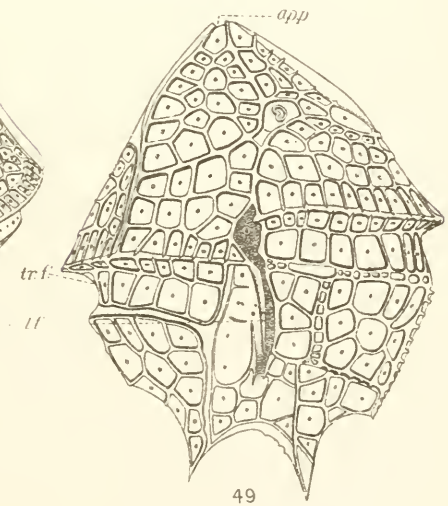

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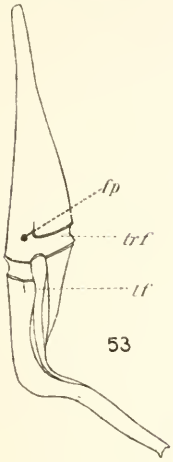
PLATE 9.

Fig. 52. *Centrodinium elongatum*, sp. nov., left face. × 450.
Fig. 53. *Centrodinium deflexum*, sp. nov., ventral view. × 450.
Fig. 54. Same, left face. × 450.
Fig. 55. *Murrayella rotundata*, sp. nov., view of right face. × 442.
Fig. 56. *Murrayella globosa*, sp. nov., ventral face. × 935.
Fig. 57. *Murrayella spinosa*, sp. nov., ventral face. × 935.
Fig. 58. *Murrayella punctata* (Cleve), ventral face. × 935.



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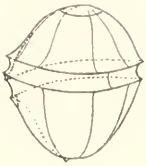

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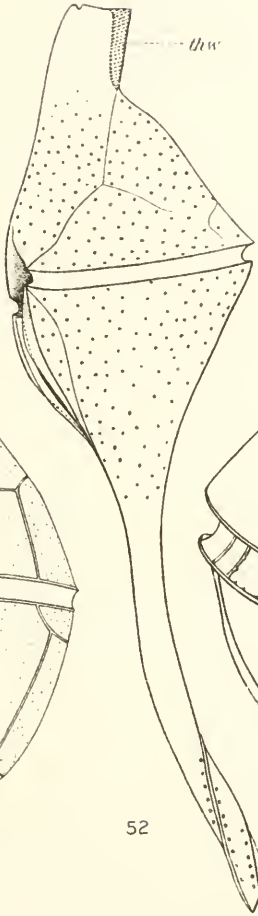

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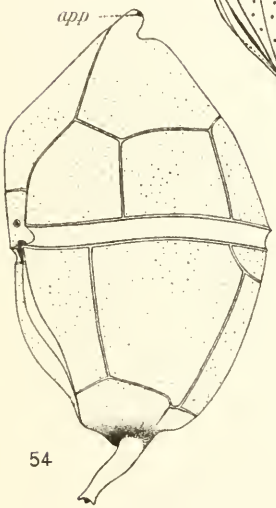

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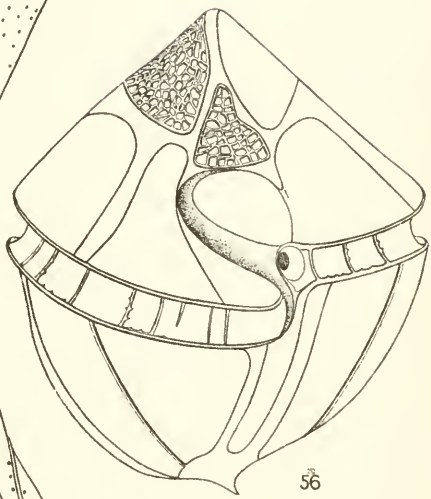

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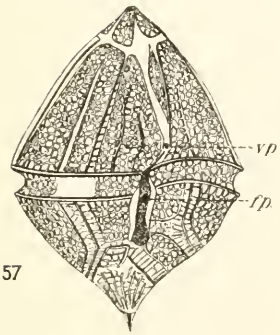

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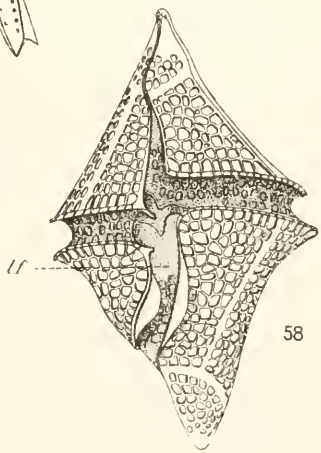

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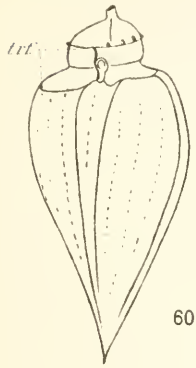
PLATE 10.

Fig. 59. *Oxytoxum gigas*, sp. nov., ventral face. × 450.
Fig. 60. *Oxytoxum turbo*, sp. nov., ventral face. × 935.
Fig. 61. *Oxytoxum curvicaudatum*, sp. nov., sinistral face. × 442. From life.
Fig. 62. *Oxytoxum subulatum*, sp. nov., dextral face. × 565.
Fig. 63. *Oxytoxum compressum*, sp. nov., oblique view of sinistral face. × 442. From life.
Fig. 64. *Oxytoxum cristatum*, sp. nov., sinistral face. × 442. From life.
Fig. 65. *Oxytoxum challengeroides*, sp. nov., ventral view, reticulations shown only on midventral postcingular plate. × 935.



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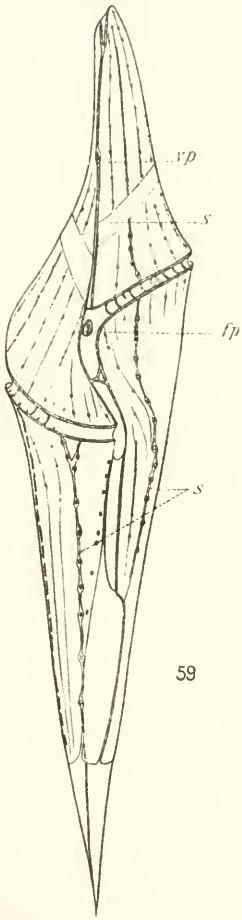

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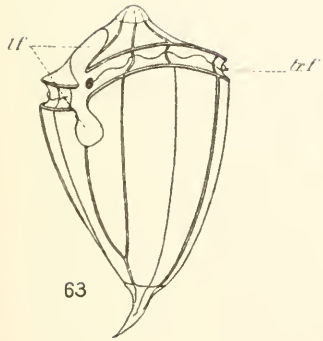

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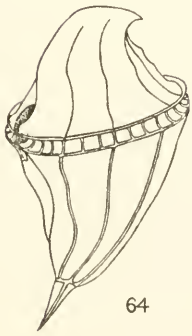

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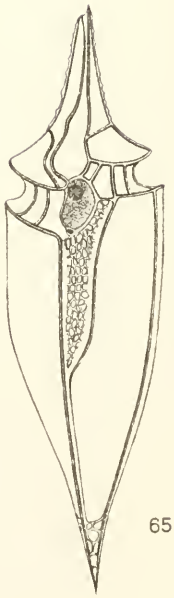

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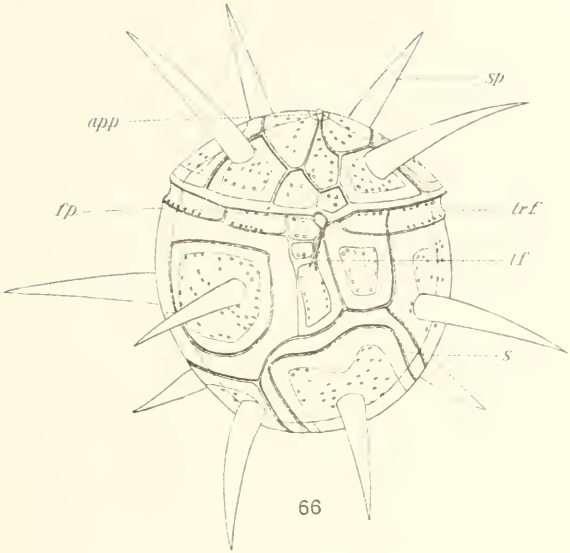
PLATE 11.

Fig. 66. *Acanthodinium spinosum*, sp. nov., ventral view. × 935.
Fig. 67. *Acanthodinium caryophyllum*, sp. nov., ventral view. × 935.



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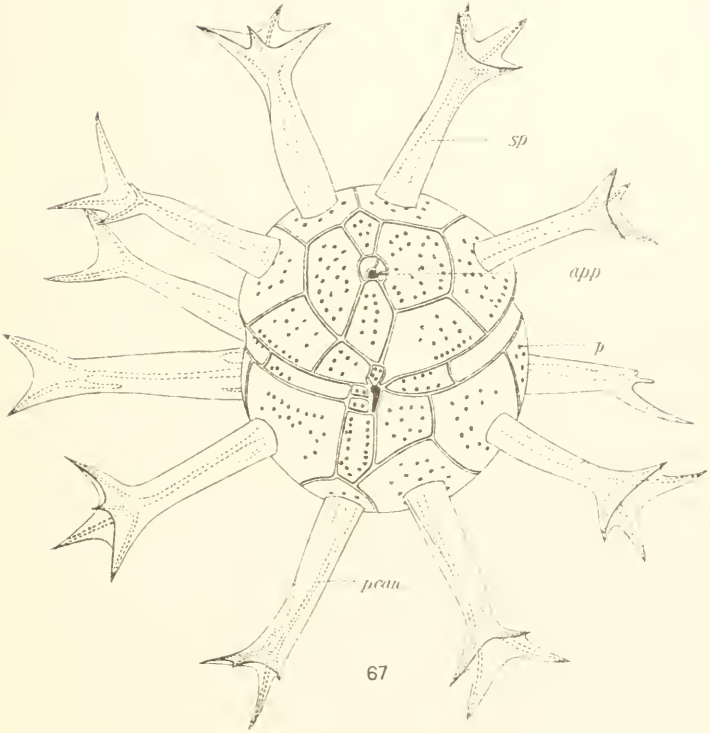

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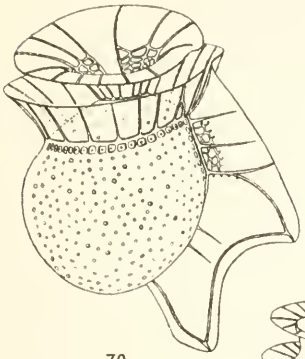
PLATE 12.

Fig. 68. *Phalacroma ultima*, sp. nov., dextral view. × 935.
Fig. 69. *Phalacroma lenticula*, sp. nov, dextral face. × 450. Reticulations only partially shown.
Fig. 70. *Ornithocercus heteroporus*, sp. nov., dextral face. × 935.
Fig. 71. *Protoceratium areolatum*, sp. nov., sinistro-ventral view. × 935.
Fig. 72. *Phalacroma reticulata*, sp. nov., dextral face. × 450.
Fig. 73. *Phalacroma striata*, sp. nov., sinistral face. × 337.
Fig. 74. *Dinophysis triacantha*, sp. nov., dextral face. × 700.



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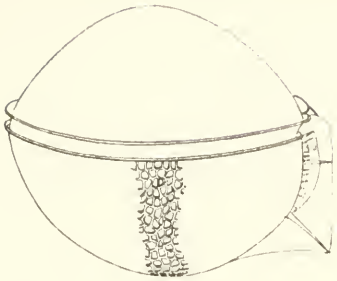

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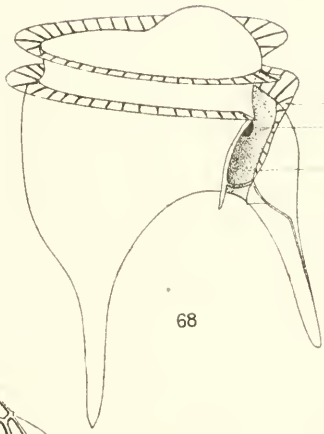

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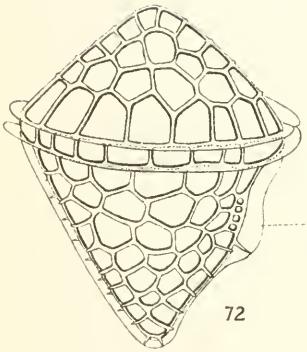

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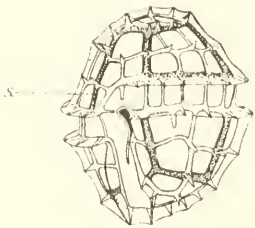

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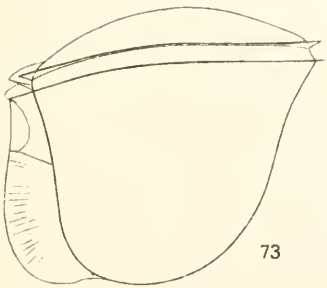

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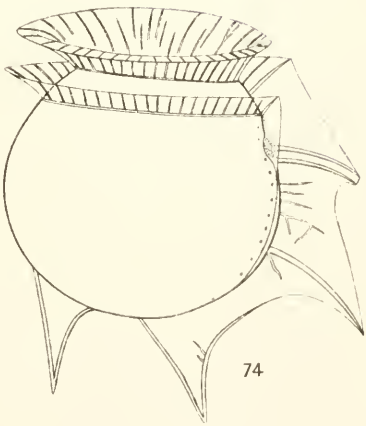

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PLATE 13.

Fig. 75. *Amphisolenia quinquecauda*, sp. nov., dextral face. × 100.
Fig. 76. *Amphisolenia asymmetrica*, sp. nov., dextral face. × 100.
Fig. 77. *Amphisolenia projecta*, sp. nov., dextral face. × 450. From life.
Fig. 78. *Amphisolenia extensa*, sp. nov., dextral face. × 100.
Fig. 79. *Amphisolenia brevicauda*, sp. nov., dextral face. × 450.
Fig. 80. *Amphisolenia laticincta*, sp. nov., dextral face. × 450.
Fig. 81. *Amphisolenia schroederi*, sp. nov., dextral face. × 300.
Fig. 82. *Amphisolenia dolichocephalica*, sp. nov., dextral face. × 100.

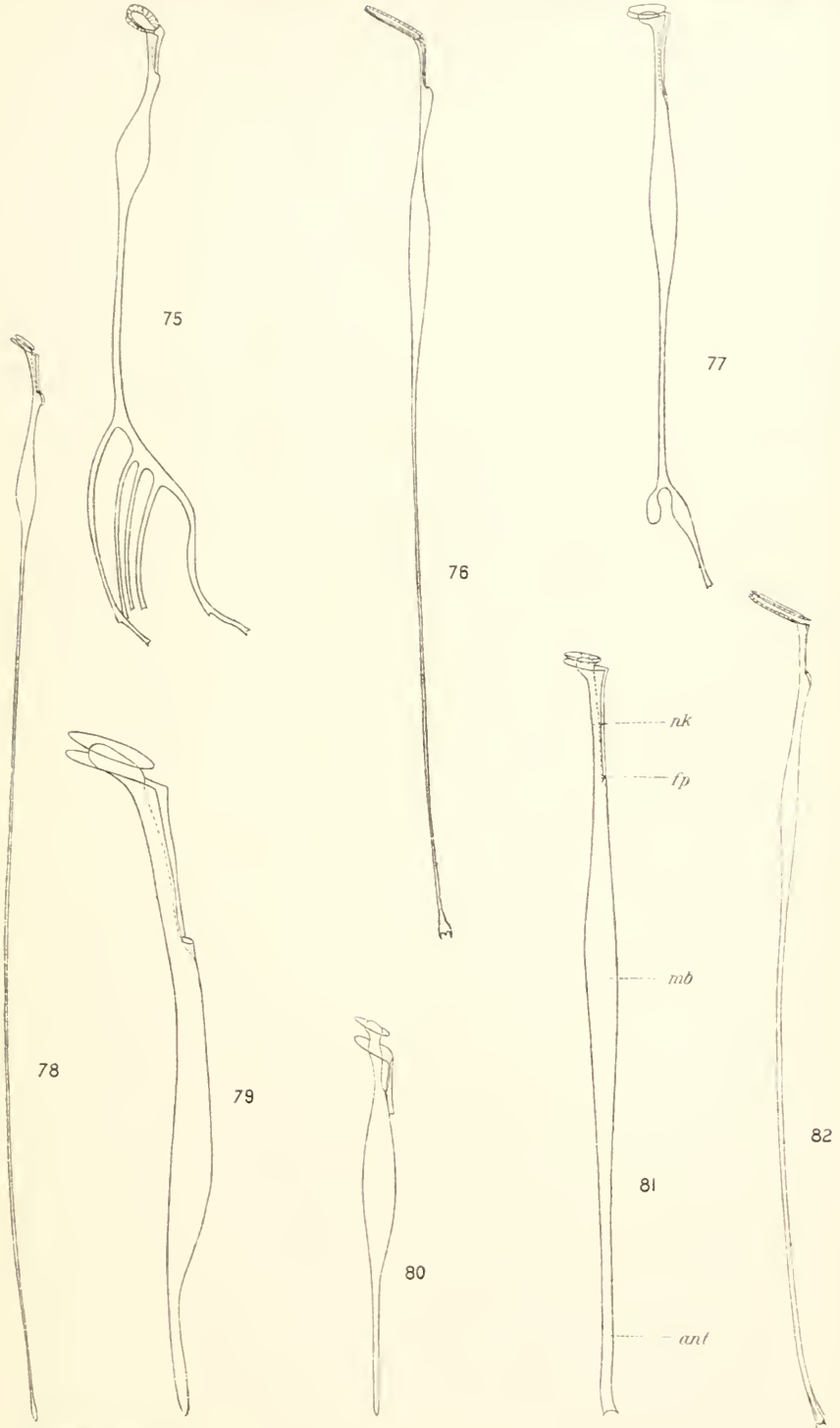
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PLATE 14.

Fig. 83. *Amphisolenia rectangulata*, sp. nov., dextral face. × 200.
Fig. 84. *Amphisolenia palaeotheroides*, sp. nov., dextral face. × 208.
Fig. 85. *Amphisolenia bispinosa*, sp. nov., dextral face. × 200.
Fig. 86. *Amphisolenia quadrispina*, sp. nov., dextral face. × 200.
Fig. 87. *Amphisolenia curvata*, sp. nov., dextral face. × 200.
Fig. 88. *Amphisolenia lemmermanni*, sp. nov., dextral face. × 200.
Fig. 89. Same, ventral view of antapex. × 200.
Fig. 90. *Amphisolenia clavipes*, sp. nov., ventral view. × 450.

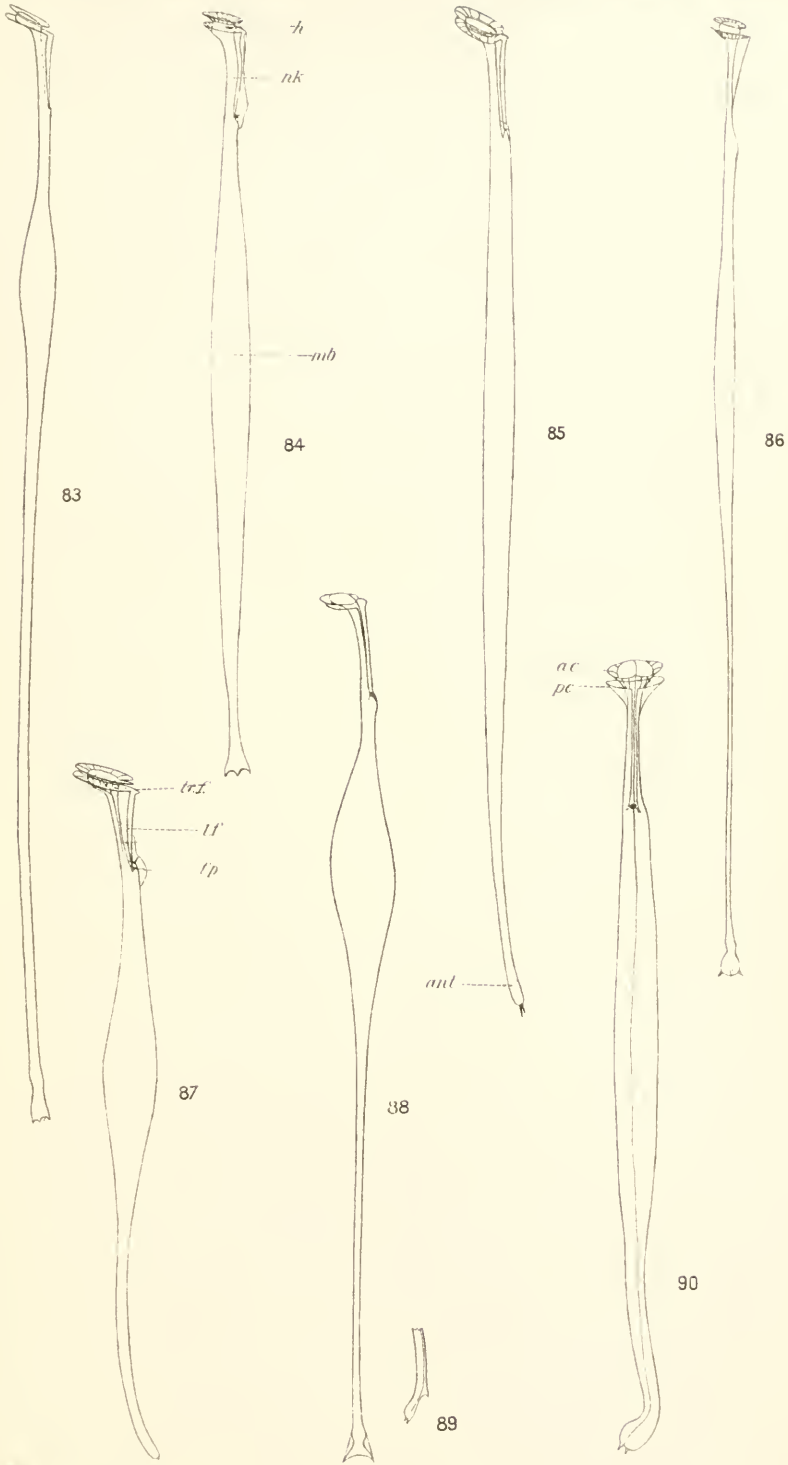
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PLATE 15.

Fig. 91. *Histioneis josephinae*, sp. nov., dextral face. × 840.
Fig. 92. *Ornithocercus carolinae*, sp. nov., dextral face. × 535.
Fig. 93. *Ornithocercus serratus*, sp. nov., dextral face. × 450.
Fig. 94. *Histioneis paulseni*, sp. nov., dextral face. × 840.
Fig. 95. *Histioneis reticulata*, sp. nov., dextral face. × 840.

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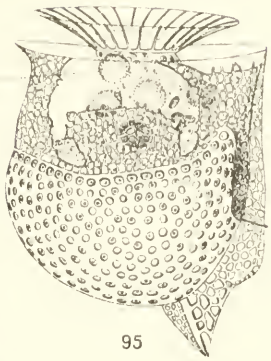

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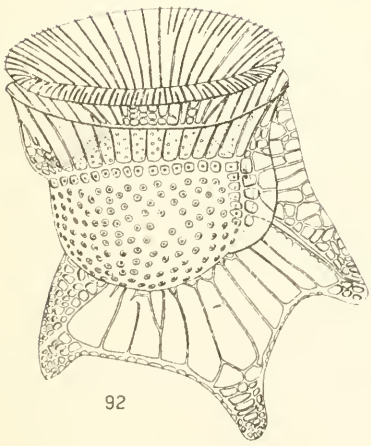

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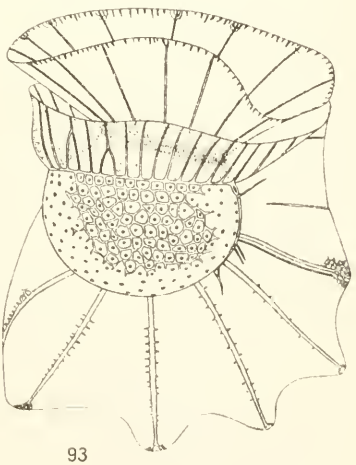

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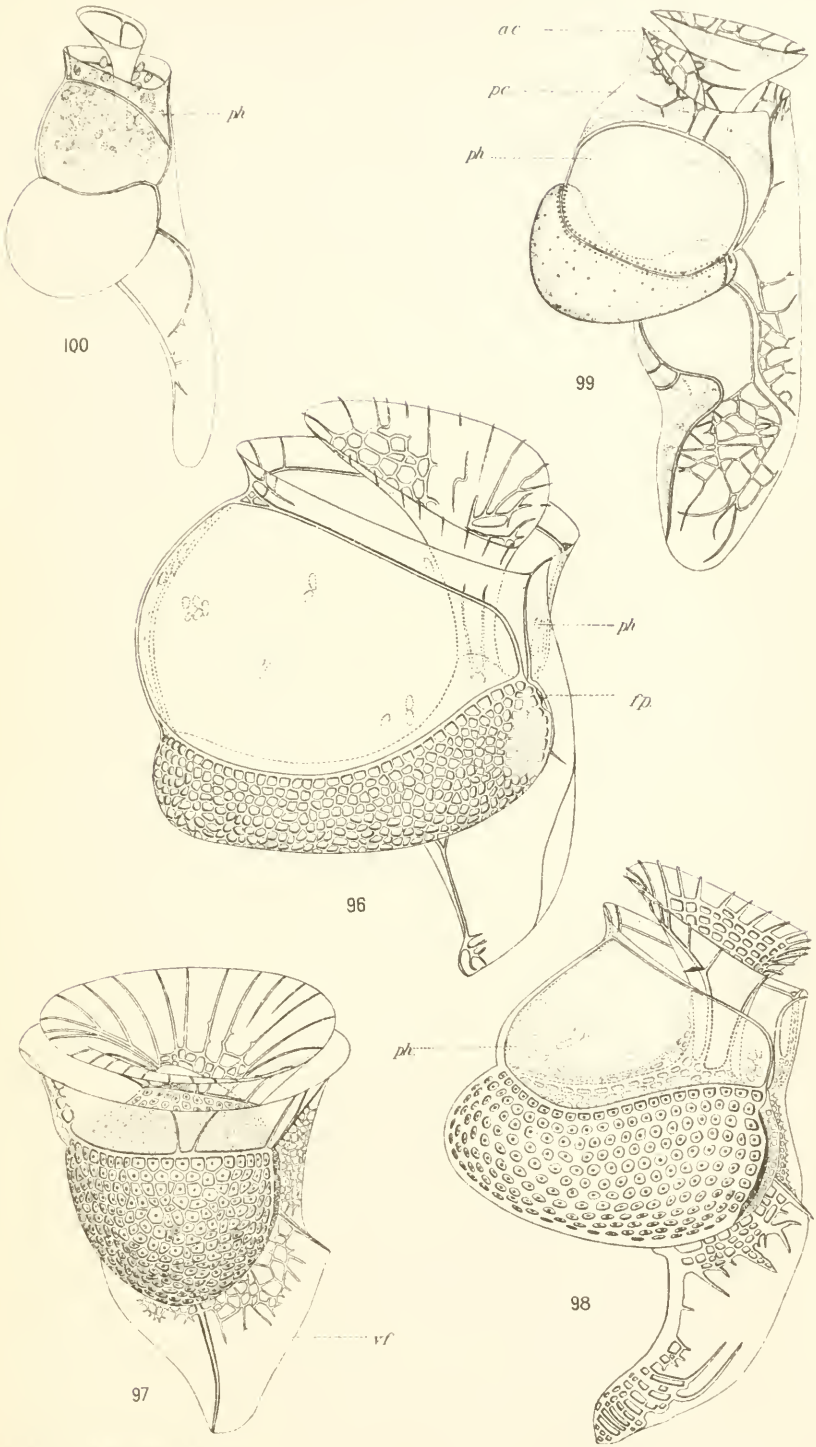
PLATE 16.

Fig. 96. *Histioneis navicula*, sp. nov., dextral face. × 840.
Fig. 97. *Histioneis garretti*, sp. nov., dextral face. × 840.
Fig. 98. *Histioneis carinata*, sp. nov., dextral face. × 840.
Fig. 99. *Histioneis pulchra*, sp. nov., dextral face. × 840.
Fig. 100. *Histioneis longicollis*, sp. nov., dextral face. × 840.



C.A.K. F. Bens A.B. C del.

PLATE 17.

Fig. 101. *Triposolenia longicornis,* sp. nov., view of right face. × 505.
Fig. 102. *Triposolenia fatula,* sp. nov., view of right face. × 505.

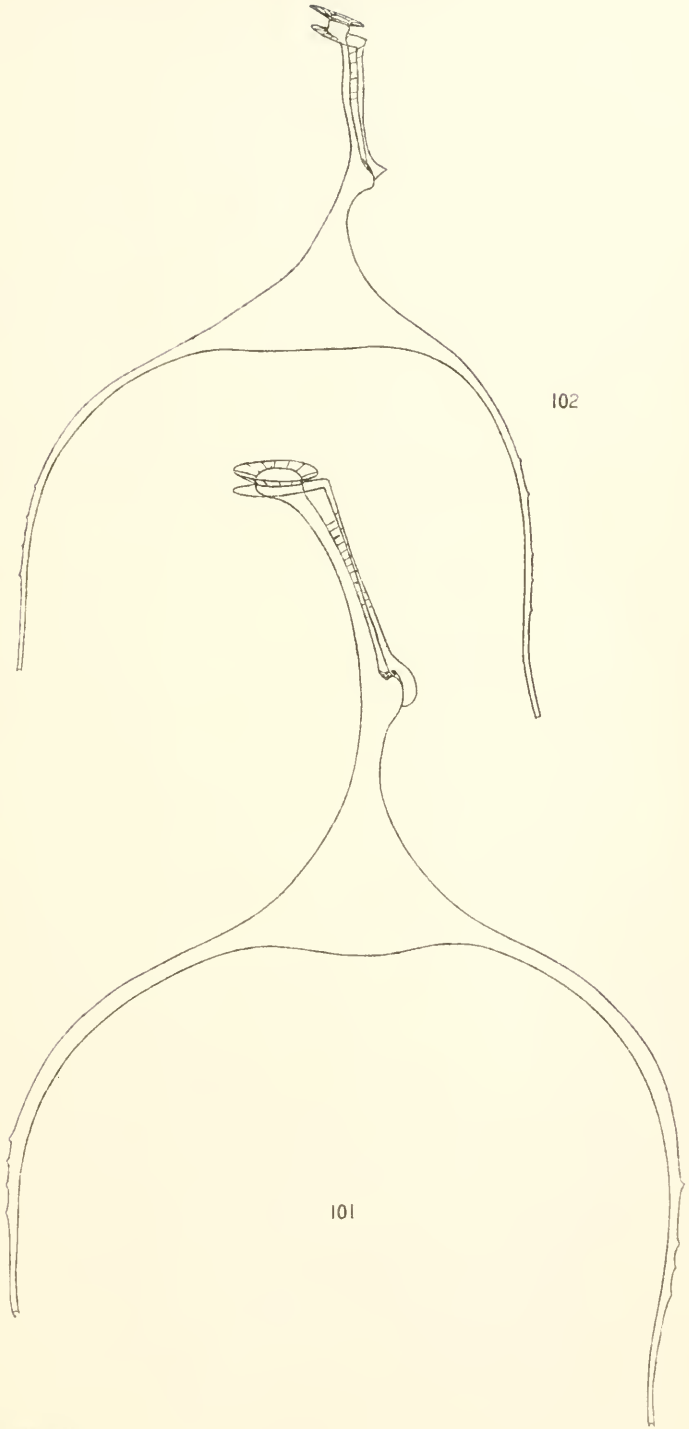

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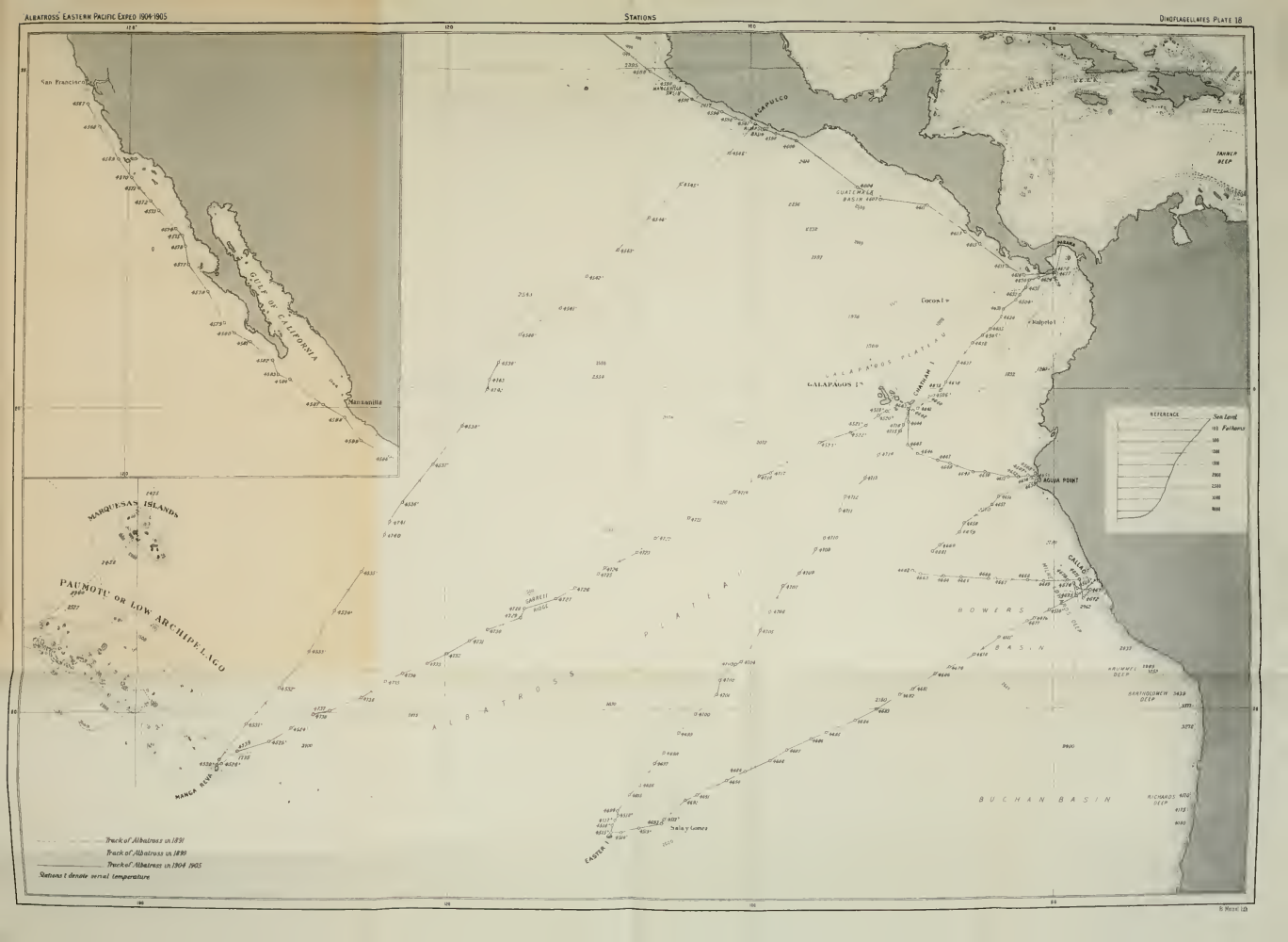
PLATE 18.

Map showing position of the stations occupied by the "Albatross" during the cruise in the Eastern Pacific in 1904–1905.


San Francisco
GULF OF CALIFORNIA
Manzanillo
MARQUESAS ISLANDS
PAUMOTU OR LOW ARCHIPELAGO
MANGA REVA I.
ACAPULCO
GUATEMALA BASIN
TRENCH DEEP
Cocos I.
Malpelo I.
GALAPAGOS PLATEAU
GALAPAGOS IS.
CHARLES I.
AGUJA POINT
CALLAO
BOWERS BASIN
ALBATROSS PLATEAU
GABRIEL
EASTER I.
Salas y Gomez
BUCHAN BASIN
KRUMMEL DEEP
BARTHOLOMEW DEEP
RICHARDS DEEP
REFERENCE
Sea Level
100 Fathoms
Track of Albatross in 1891
Track of Albatross in 1899
Track of Albatross in 1904-1905
Stations denote vertical temperature

Bulletin of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. L. No. 7.

MYLOSTOMID DENTITION.

By C. R. Eastman.

With One Plate.

CAMBRIDGE, MASS., U. S. A.:
PRINTED FOR THE MUSEUM.
February, 1907.

No. 7. — *Mylostomid Dentition.* By C. R. Eastman.

The reconstruction of the Mylostomid type of dentition acquires significance through its relevancy to the larger question of the affinities of Arthrodires. Nature has not disclosed to us by direct evidence the manner in which upper and lower dental plates of Mylostomids functioned against one another during life. The disposition of the various parts must therefore be determined by indirect means, such as by observing evidence of co-adaptation, mutual contact and wear, and, so far as may be, through analogy with related forms. In reality the problem is a simple one, devoid of mystery and intricacy, and requiring little mechanical ingenuity for its solution and complete verification. Of trivial intrinsic importance, its solution promises enlightenment as to the relations of the perplexing group of Arthrodires. A matter of minor interest in itself, it determines consequences of real magnitude, and hence is worthy of thoughtful consideration. It is proposed in the following pages to examine into the general nature of the problem, the different solutions that have been proposed for it, and some of the consequences depending thereon.

The limiting conditions of the problem may be stated first. Mylostomids are known upon the evidence of two fairly well-preserved skeletons to be Arthrodiran fishes essentially like Dinichthys, except that their dentition is adapted for crushing instead of cutting. The two specimens referred to are the only ones thus far discovered which present us with the disarranged but nearly complete dentition of single individuals. The fact that in each case the dental elements are known positively to have belonged to a single individual not only facilitates their reconstruction, but furnishes a scale of relative proportions which may be presumed to hold constant throughout the species. Thus provided with a standard of comparison, we may select from a sufficiently large assortment of detached plates the necessary components of a complete dentition, all of whose parts shall be proportionate with respect to one another, and shall have precisely the same conformation as those known to have been associated in a single mouth. Or, given a detached mandible of the same configuration as those found in natural assemblage with other parts,

the size of the upper dental plates which must have accompanied it during life can be predicted with entire accuracy.

Experience having shown that all of the dissociated dental elements now known, upper and lower, exhibit among themselves practically uniform dimensions and uniform conformation, one is entitled to conclude therefrom that they represent average-sized individuals, and that the elements were arranged after an invariable pattern. For, supposing their disposition to have been inconstant, we should be at a loss to account for their marked regularity of form and proportion, and similar indications of wear. Hence any theoretical reconstruction of the dentition, whether based upon detached specimens or upon the evidence of naturally associated parts, must satisfy the test of totality. It must apply universally, not only to such plates as are known to have belonged to a single individual, but to all those that have been found in the detached condition as well; it must be compatible with all their essential features, and be negatived by none of them.

It may be that only one, or more than one theoretical reconstruction of the dentition is competent to explain all the observed facts. As between two rival hypotheses, that one may be regarded as the more plausible which is mechanically simple, free from anomalous suppositions, and in harmony with analogy. An hypothesis which is mechanically complicated, presupposes anomalous conditions, and violates analogy, is less worthy of credence. For in so far as it depends upon the assumption of the unique, of something for which nature affords no parallel, it becomes improbable; and the improbable is always to be distrusted. Speaking broadly, any hypothesis whatsoever has the elements of trustworthiness, provided it can be shown to agree with a number of diverse facts. The greater number of diverse facts with which it agrees, the more completely can it be verified. When many circumstances point toward a single conclusion, the chances of that conclusion being correct are enormously increased with each additional favoring circumstance. They might even be supposed to increase in geometrical rather than in arithmetical ratio. Finally, an hypothesis that is found to agree entirely with observed facts cannot but be believed to be true. It will be instructive to inquire how far either of the two extant interpretations of Mylostomid dentition are in accordance with observed facts.

Newberry's Views. — Our earliest information regarding the Mylostomid type of dentition is due to the zeal and acumen of Professor J. S. Newberry, who described the constituent elements of the type species,

M. variabile, and also founded a second species, *M. terrelli*, upon the evidence of a solitary mandibular plate. He noted the general correspondence between the Mylostomid and Dinichthyid type of mandible, and observed that the former occurred together with two distinct varieties of "flattened tabular dental plates . . . exhibiting the same microscopic structure," which were properly referred to the upper dentition of the same species. He made no effectual attempt, however, to work out the arrangement of the pavement teeth, merely observing that their "sides are straight or bevelled, apparently for co-adaptation, and by this character favor the conclusion that the dentition consisted of many pairs of plates, constituting a tesselated pavement; the crowns of the teeth below being convex, those above concave."[1] The front margin of the mandibular plates was also considered by this author to show evidence of co-adaptation with other dental structures; and in order to satisfy the hypothetical requirements thus created, a pair of "premandibular" elements was not only postulated by him, but two specimens figured in his monograph[2] were actually referred to this position, albeit with some reservation. We will return later on to a discussion of these so-called "premandibular" plates, under a separate heading.

Newberry's investigations of Mylostoma served to acquaint us in all, as he supposed, with four pairs of dental structure, one of which was correctly identified as belonging to the lower, and two to the upper jaw, while the position of the fourth was acknowledged to be uncertain. His reasons for referring these various pairs to a single species are that they were found to occur together, and to exhibit identical structure and surface markings. The circumstances of their discovery are not related in detail, but it is significant that all specimens of Mylostoma known to Newberry, excepting the type of *M. terrelli*, were obtained by one collector from a single horizon and locality, namely, the Cleveland shale of Sheffield, Ohio. Newberry's suggestion that several pairs of plates besides these four took part in the complete dentition, and that the upper series formed a tesselated pavement, shows that he had only a vague and illusory idea of their arrangement. He even confused the right and left mandibular plates. His work was essentially that of a pioneer, and as such is praiseworthy, although necessarily imperfect. It was at Dr. Theodore Gill's suggestion that he undertook the first comparisons between the dentition of Arthrodires and Dipnoans, the

[1] Newberry, J. S., The Palaeozoic Fishes of North America. Monogr. U. S. G. S., 16 (1889), p. 166.

[2] *Ibid.*, p. 161, 165, Plate 16, Fig. 4.

former's ideas as to the relations of Homosteus having been published as early as 1872.

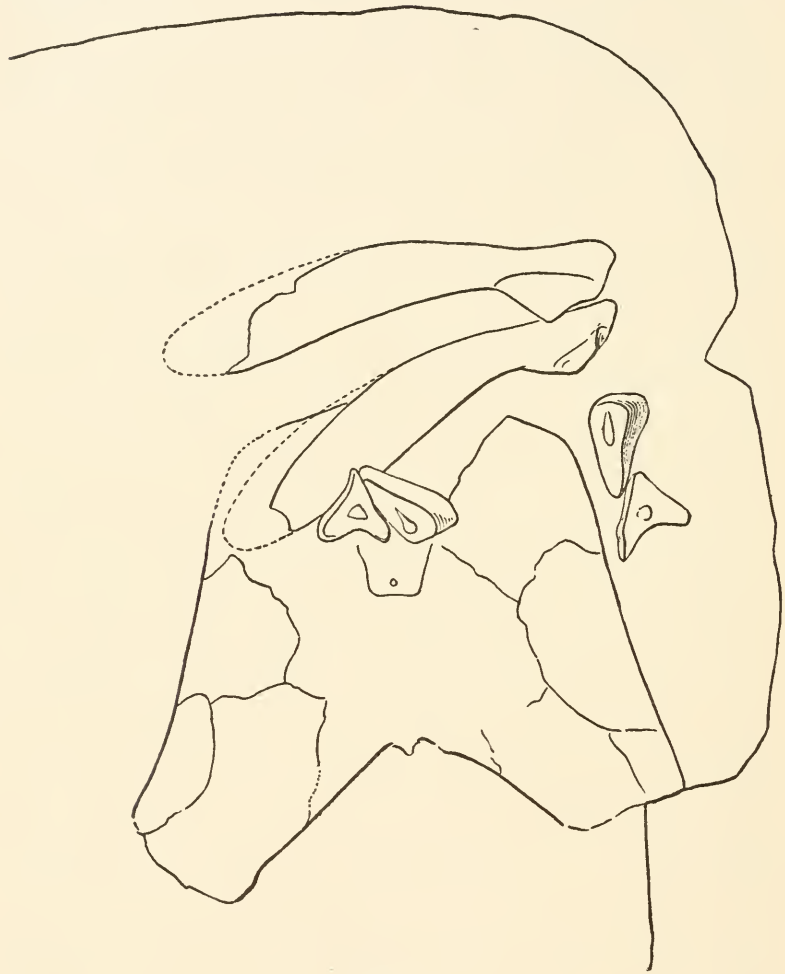


FIGURE *A*.

Outline sketch showing the position in which the constituent parts of the dentition were embedded with respect to the headshield in the block of shale containing the single individual of *Mylostoma variabile* juv. Museum Comp. Zoöl. (Cat. 1490); Amer. Mus. Nat. Hist. (Cat. 7526). × ½. (After Dean.)

DEAN'S INTERPRETATION. — To Professor Bashford Dean belongs the credit of having attempted the first serious and thorough-going restoration

of the dental apparatus of Mylostoma, his interest in the problem having been aroused by the discovery of a well-preserved skeleton of *M. variabile*, the various parts of which obviously belonged to a single individual. This specimen presented for examination the flattened headshield, some half-dozen plates of the abdominal armor, both mandibles, and two pairs of crushing dental plates, all embedded in close proximity to one another in a single block of shale. There were no indications, however, of the presence of a fourth pair of dental elements, corresponding to the so-called "premandibular teeth" of Newberry, and these latter do not enter into Dean's reconstruction.

As will be seen from Figure *A*, which is copied from Dean, the two mandibular rami were found lying nearly parallel to each other in close

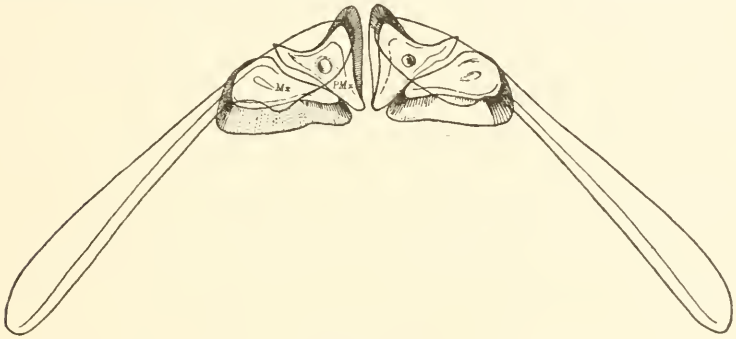


FIGURE *B*.

Restoration of the complete dentition of Mylostoma, based upon the single individual of *M. variabile* shown in Figure *A*. The length of the mandibular dental plate is slightly exaggerated in the outline here shown. × ⅓. (After Dean).

proximity to the headshield, and at no great distance from the separated halves of the palatal dentition. The two plates interpreted by Dean as belonging to the right-hand side of the palate are in direct apposition with each other, their contact edges being in remarkably close adjustment. These circumstances, the fact that the two right-hand palatal plates remain together while the corresponding left-hand plates have become separated, and the fact that their opposed edges show almost perfect co-adaptation, are held by Dean to point irresistibly to the conclusion that the elements in question have preserved their natural arrangement with respect to each other.[1] It is not demonstrated by the author, but merely considered as extremely probable that

[1] Dean, B., Palaeontological Notes. Mem. N. Y. Acad. Sci., 1901, **2**, p. 104.

the relations of these plates have not been disturbed; and this inference is made by him the determining factor of his restoration (Fig. *B*), the starting-point of his theory of rotary jaw-movements, and the key-note to a novel interpretation of Arthrodires. One perceives, accordingly, that extremely weighty conclusions depend upon Dean's initial assumption, the truth or error of which requires to be demonstrated. Sufficient reason for distrusting its correctness is found in the improbability of the conclusions resting upon it, the more important of which are contrary to analogy. We may therefore profitably inquire into the reasonableness of the author's initial assumption, and ascertain, if possible, to what extent it invites confidence.

The one clearly demonstrable feature of the single specimen of Mylostoma studied by Dean is that the right and left halves of the palatal dentition have become separated; and that, although the components of either half remain in association, they are dissimilarly oriented. This state of affairs permits of three possible explanations, which may be stated as follows: —

1. The two right-hand palatal plates have preserved their natural orientation with respect to each other, and the two left-hand plates alone have become disarranged.

2. The two left-hand palatal plates retain their natural orientation with respect to each other, and the two right-hand plates have become disarranged.

3. The components of both halves of the palatal dentition have become turned about, so that none of them any longer occupy their original position with respect to one another.

Circumstantial evidence is our only resource for determining which one of these conclusions is correct. A strong point in favor of the first is the neat adjustment between the contact edges of the plates, which are preserved in direct apposition. At the same time, the close fit observed between the two nearly straight edges cannot be regarded as really decisive proof, owing to the possibility of its being the result of chance. The two right-hand palatal plates may or may not be retained in natural position; the only test that can be absolutely relied on for determining their arrangement, the real *experimentum crucis*, consists in bringing the functional surfaces of the two upper dental plates into harmonious adjustment with the mandibular, so that a number of diverse features of both upper and lower dental plates shall stand in reciprocal relations. When tubercles are found to fit into grooves or pits, eminences into depressions, and marks of wear to coin-

cide at all points we have evidently found the true arrangement; since only in this manner could the parts have interacted during life. Application of this test to the single individual of Mylostoma we are considering, and also to an extended series of detached plates, shows that Dean's reconstruction fails to explain all the facts, and only explains some of them by positing anomalous, and *pro tanto* improbable conditions. In a word, the arrangement is unable to satisfy the test of totality. It is, therefore, inadequate, and the initial assumption upon which it is based must be regarded as erroneous.

The principal objections to Dean's reconstruction may be thus summarized: —

1. The proposed arrangement necessitates the assumption of jaw-movements in Arthrodires which are unparalleled amongst Chordates.

2. No close analogy is suggested by this arrangement with the dentition of related forms.

3. Some conspicuous indications of wear, the position of which is constant in all plates thus far brought to light, are wholly unaccounted for by this arrangement.

4. According to this arrangement, the marginal contours of upper and lower dental plates do not coincide. A considerable portion of the oral surface of all the plates is left uncovered when the jaws are closed, even including areas which show indications of wear.

5. One of the two palatal plates found lying in apposition in the nearly complete example of Mylostoma (the one called "premaxillary" by Dean) is observed to present a worn surface immediately adjoining the contact margin with the so-called "maxillary" element. The latter, however, is unworn along the contact margin, but is raised there into a prominent ridge. Supposing these plates to have been naturally in contact, they must needs exhibit similar evidence of attrition along their common margin; since they do not, they must have been arranged in some other manner.

6. The only strictly linear margins of any of the plates are not in contact with each other, nor are the members of either pair in direct apposition along the median line.

Eastman's Interpretation. — The arrangement proposed by the present writer was first established upon the evidence of detached plates, which were fitted together conformably to the marginal contours of upper and lower dentition, and in such manner as to account at all points for reciprocal marks of wear. Its efficiency was afterwards tested by applying the same arrangement to the single example of Mylostoma

studied by Dean. The two left-hand palatal plates being removable from the specimen, they were rearranged in the prescribed manner, and their oral surfaces fitted against the mandibular dental plate. The experiment was also repeated with the aid of plaster casts of the two right-hand palatal plates, which were not removable, and in both cases the new arrangement was found competent to explain all the facts in thoroughly satisfactory manner. Its effectiveness will be readily understood from inspection of Figure *C*, drawn from the original specimens, and from the following discussion of details.

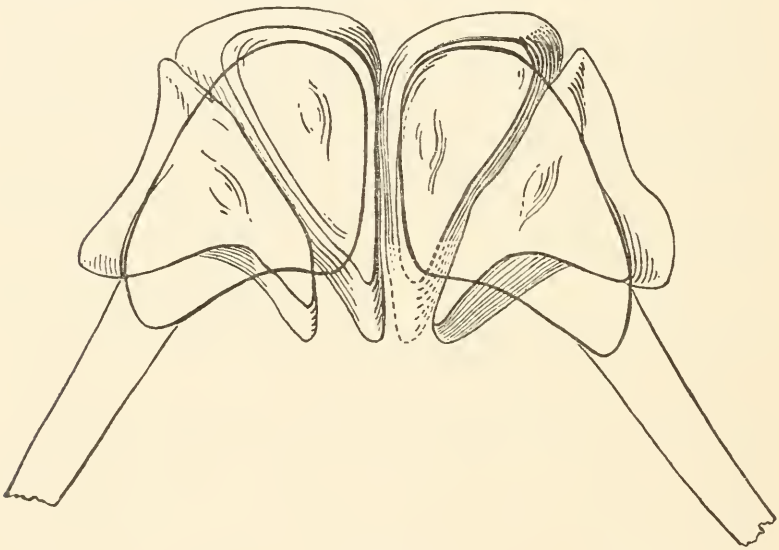


FIGURE *C*.

Proposed reconstruction of Mylostomid dentition, based upon the originals shown in preceding text-figures. × ½.

We have already stated that the juxtaposition of dental plates in the nearly complete example of Mylostoma is such as to admit of three possible conclusions, only one of which can be true. The new arrangement proceeds to test, and afterwards to affirm the correctness of the second of these conclusions, which are here restated for sake of clearness.

1. The two right-hand palatal plates are retained in their natural position with respect to each other. (Disproved.)

2. The two left-hand palatal plates are naturally oriented with re-

spect to each other, and the two right-hand plates have become disarranged.

3. None of the palatal plates retain their natural position with respect to one another.

By orienting the two right-hand plates in corresponding fashion to the two left-hand, and then approximating the disjoined halves of the dentition, a symmetrical pattern is formed, such as is shown in Figure *C*, and repeated in Plate 1. An obvious feature of this arrangement is that the only elongate linear margin of any of the plates is directed parallel to the median line, and it is along this line that the paired elements having a single straight margin are mutually in contact. The evidence of co-adaptation presented in this respect is sufficiently striking, and it will be at once recalled that analogous conditions are found in various types of Dipnoan dentition.

We have now to apply the most crucial test open to us with the means at our command. It consists in bringing the functional surfaces of mandibular and palatal plates together and observing the extent of their mutual correspondence. Immediately this is done it becomes patent that a close coincidence exists between the contour lines of upper and lower dentition; the jaw-parts fit together as accurately as may be when the mouth is closed, and their impact is exactly such as is capable of producing the observed marks of wear. The triturating areas that were left uncovered in the preceding restoration (Fig. *B*) are now brought into much closer adjustment above and below, the contrast presented by Figure *C* in this respect being self-evident. It thus appears that the fourth in the list of objections to Dean's arrangement (*v.* p. 217) is inapplicable in the present instance.

Amongst other constant features of the anterior pair of palatal plates are to be noted the following: The linear inner (ental) margin is elevated into a distinct ridge, which increases in height and breadth in the vicinity of the antero-internal angle of the plate, where it shows evidence of attrition. The marks of wear extend not only along the side of this ridge, but also over the concave surface of the plate immediately adjacent to it. The summit of the elongate, mesially placed tubercle is worn, and the sunken area in advance of this, extending as far as the antero-external angle is the most conspicuously worn of all. This concavity is particularly well displayed in the detached specimens figured by the writer in Bulletin Mus. Comp. Zoöl., 50, no. 1, Plate 1, Figures 2, 3. Now, the significance of all these features becomes apparent when the functional surface of the plate in question is applied

against the mandibular in the manner already described. On bringing the two surfaces together, all marks of wear observable in the anterior palatal plate are seen to coincide with similar worn areas of the opposing plate, thus fully disclosing their mutual relations.

The ental margin of the mandibular plate fits just within and against the side of the ental ridge of the palatal plate, and closes against the thickest and highest portion of the ridge near the antero-internal angle, where both plates are deeply worn. The ectal rim of the mandible fits accurately into the broad and deeply worn concavity of the palatal plate, the surface of the one being a faithful replica of the other, and the relations between them being comparable to those of a die-stamp. The extremely prominent bifid eminence which rises midway the length of the mandibular plate along its ental margin functions within the depressed posterior surface of the palatal, and the longitudinal cleft by which the eminence is divided embraces the elongate, mesially placed, and longitudinally directed tubercle of the palatal plate, whose summit fits into a shallow groove of the mandibular plate. Thus an interrelationship between all the parts is demonstrable, which must faithfully indicate their natural arrangement, since no other is capable of producing the observed effects. Having ascertained the relations of the anterior palatal plates, it is an easy task to bring the hinder one into adjustment with it and with the remaining portion of the lower dentition.

The posterior palatal plate may be described as approximately cordiform, or subtriangular. Not more than two of its borders are straight or slightly concave, the third being profoundly indented, and for that reason incapable of direct contact with the preceding element. The contact margin must therefore have been formed by one or the other of the nearly linear sides, and by experimenting with them in connection with the two plates whose relations have already been determined, it is readily perceived which one of these sides permits of harmonious adjustment. The pointed anterior extremity of the plate we are now considering adapts itself regularly to the outer contour line of the mandible; its worn centrally placed tubercle fits into a depression of the lower plate; and its marginally situated tubercle closes just back of the elevated prominence of the mandibular plate, playing into a declivity that occurs on the inner face of the latter. The surface irregularities of both plates, together with all their indications of wear, are thus fully accounted for by this arrangement. Noteworthy also is the fact that precisely similar relations obtain in Dinomylostoma, where the orien-

tation of the posterior palatal plates is determined with absolute accuracy. Another point confirmatory of the new arrangement is that in the nearly complete example of Mylostoma (Fig. *A*), the posterior pair of palatal plates occurs symmetrically oriented with reference to the median line. From this it is evident that the only one of the four palatal plates whose position has been disturbed, aside from lateral displacement, is the right anterior.

The present reconstruction of the palatal dentition of Mylostoma thus provides a consistent explanation of all observed facts, and is at variance with none of them. It is free from theoretical objections, is in harmony with analogy, both with Dinichthys and Ceratodonts, and is applicable to all specimens thus far discovered, whether found in the detached or associated condition. Its correctness may therefore be regarded as definitely proved. Up to the present point the discussion has been purposely restricted to the palatal and mandibular dental plates.

Concerning those structures interpreted by Newberry as "premandibular," and by the present writer in earlier papers as "vomerine" teeth, it is now necessary to speak more particularly. I purpose showing that the three known specimens which have received this designation do not belong to the type species of Mylostoma, but to a smaller, very distinct form, presently to be described under the name *M. newberryi*. Moreover, the specimens in question are no longer interpreted as vomerine, but as mandibular plates which have become accidentally dissociated from their supporting splenials, or from the greater part of these bones. The presence of vomerine teeth in Mylostoma is therefore not yet demonstrable by any positive evidence that has come to light, although their potential occurrence is to be inferred from analogy with Dinomylostoma and Coccosteans generally.

Indications of a New Species of Mylostoma. — As already stated, Newberry was of the opinion that the lower dentition of Mylostoma consisted of at least two pairs of dental plates, mandibular and "premandibular," opposed to which in the upper jaw was a "tesselated pavement consisting of many pairs of plates." Bashford Dean was enabled to show that the upper pavement dentition was made up of two pairs of plates only, against which functioned the single mandibular pair. In the nearly complete example of *M. variabile* studied by this author no trace was observed of yet another fourth pair of dental structures, corresponding to those named premandibular by Newberry, and vomerine by the present writer. The originals of Newberry's figures do not enter

into Dean's restoration of the Mylostomid dentition, nor is their existence mentioned. As a matter of fact, the actual specimens had been lost sight of for many years, and in the absence of satisfactory illustrations it was difficult to hazard a conjecture as to their nature. Without having studied the originals, no one could have concluded that they had suffered such injury as to obscure their real nature, nor could any good reason be assigned for excluding them from association with the type species of Mylostoma.

By a fortunate chance the original pair of Newberry's so-called "premandibular teeth" have been preserved intact in the Museum of Oberlin College, where they were overlooked until recently. Being recognized by Dr. Hussakof, after searching various collections, they were loaned to him and subsequently placed in the hands of the present writer for purpose of further study and description. Grateful acknowledgments are hereby rendered to the writer's colleagues in New York and Oberlin for having thus provided an opportunity for the following observations.

Comparison of the original pair of dental elements figured in Plate 16, Figure 4, of Newberry's Monograph with the lower dental plates of Mylostoma, especially those of the single individual of *M. variabile* described by Dean, leaves no room for doubt that they are of similar nature. We have not to do with integral paired structures representing a distinct element, but with a fractured pair of mandibles belonging to a new species of Mylostoma. The inferior aspect in particular of Newberry's originals displays the usual conformation of grooves, ridges, and hollows with which we are familiar in Mylostomid mandibles. One of these grooves is extremely characteristic of the Arthrodiran type of mandible, always occupying the same position, and from its similarity to a corresponding groove in modern Dipneumoni, has been interpreted as serving to lodge remnants of the Meckelian cartilage. The line of fracture along which the posterior shaft of the splenial has been broken off is irregular, even ragged in places, and so obviously the result of injury that it is surprising Newberry should not have noticed it. Curiously enough, in the case of the solitary known specimen agreeing with the typical pair, the same which we have previously called "vomerine," signs of injury are scarcely to be perceived, and would seem to have become almost wholly obliterated by post-mortem attrition. Yet it follows by implication that the Cambridge specimen has likewise suffered the loss of the supporting splenial.

There can be no question that the Oberlin pair of mandibular plates

belonged to a single individual. This is shown by their almost perfect symmetry, similar texture, equal extent of wear, and especially by the evidence of co-adaptation along their linear inner margins, where they were in contact along the median line. The indications of a rigid cartilaginous union at the symphysis are of an even more positive character than in Ptyctodonts, for in these plates the contact line is more extended, and the adjustment along the vertical inner face more accurate. On bringing these surfaces into adjustment, it is easy to see from the alignment of the splenial portions that the angle subtended by the mandibular rami must have been very narrow. The pointed form of the plates in front leads also to the conclusion that the head was sharp-snouted, slender, and elongate, indicating a creature adapted for rapid motion, and possibly one having an eel-like form of body.

A marked feature of the mandibular plates as compared with those of the type species of Mylostoma is the narrowness of their functional surface, with tapering forward extremities, a character by which the new form is readily distinguished from all other Mylostomids. The triturating surface is moderately convex, and displays the usual tubercle along the inner margin, although this is less elevated than in other species, and is more distinctly separated from the posterior portion of the plate by a deep sinus. This is the concavity referred to in Newberry's description, where it is suggested that the posterior margin of the "premandibular" plates is "obliquely notched, apparently to receive the obtuse points of the larger teeth." In addition to the main eminence along the inner margin, faint indications are visible in the Cambridge specimen of two or three rows of smaller tubercles, radiating outwards in a manner strikingly suggestive of Ctenodipterine teeth. Similar markings were no doubt present in the Oberlin examples as well, but have become obliterated by wear. Their larger size and more worn condition suggest that they pertained to an older individual than that represented by the Cambridge specimen (M. C. Z., Cat. no. 1439). The form of all three strongly recalls Ctenodipterine conditions, and it is probable that the resemblance extended to the upper dental plates as well. They were no doubt attenuated anteriorly in corresponding fashion with the mandibular plates, their oral surfaces were regularly concave and very possibly tuberculated, and it would not be at all surprising if the two pairs of upper dental plates common to other Mylostomids were in this species fused into one. This would give rise to a compact triangular-shaped plate, closely paralleling those of typical Dipnoans.

The new species may appropriately be named in honor of the memory

of Professor Newberry. Its principal characters are summed up in the following definition.

Mylostoma newberryi, sp. nov.

Fig. D.

1889. *Mylostoma variabilis* Newberry, Mon. U. S. Geol. Surv. **16**, p. 165, plate **16**, fig. 4 (*non* figs. 1–3).

1906. *Mylostoma variabile* Eastman, Bull. Mus. Com. Zoöl., **50**, p. 22, plate **1**, fig. 7 (*non* figs. 1–5, 8–9).

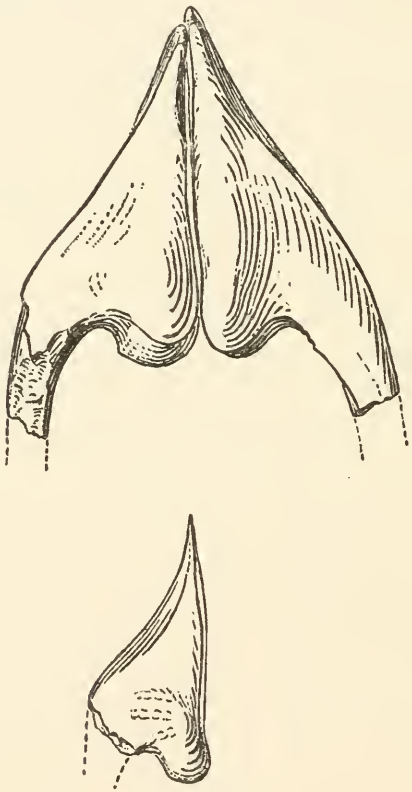


FIGURE *D.*

Mylostoma newberryi, sp. nov. Cleveland shale; near Sheffield, Ohio. *Above*, the original pair of Newberry's so-called "premandibular teeth," here interpreted as mandibular (Oberlin Museum Cat. 1302). *Below*, a smaller left mandibular plate (Museum of Comparative Zoölogy Cat. 1439). × ½.

An imperfectly known species, established upon the evidence of mandibular dental plates which have become accidentally dissociated from their supporting

splenials. Functional surface moderately convex, of narrow, subtriangular outline, tapering and acutely pointed in front, with elongated linear inner margin showing distinct evidence of coadaptation along the median line, and notched posteriorly in the vicinity of the single rounded eminence into which the ridge along the inner margin gradually rises. Adjacent to this eminence are to be seen in unworn specimens a few rows of small rounded tubercles, radiating outwards, but tending to become obliterated by use, and the larger eminence tending also to become worn down. Oral surface sloping gradually towards the bevelled external margin, but falling precipitately along the inner and posterior borders. Under surface displaying the characteristic ridges and depressions of Mylostomids, besides the usual groove for lodging remnants of the Meckelian cartilage. Jaw-angle acute, indicating a very slender, possibly anguilliform body.

Homologies of Mylostomid Dental Plates. — Throughout the foregoing section we have employed the term "palatal plates" merely as a convenient designation for the paired elements forming the upper pavement dentition of Mylostomids, without having precisely indicated their relations to other forms of crushing dentition. Newberry may possibly have assumed, although his writings nowhere indicate it, that these plates are homologous with the dental elements in the upper jaw of Dinichthys and other Arthrodires. He did, however, point out their obvious resemblance to the single pair of upper dental plates in Ceratodonts, his remarks on this subject being as follows :[1]

"The resemblance of the teeth which I have supposed formed the roof of the mouth to those of *Ceratodus* will strike any one who examines them, and no closer analogy suggests itself in the whole range of ichthyic dentition. There is, however, this marked difference, that while in *Ceratodus* there is only one pair of dentary [*i. e.*, dental] plates borne on the palato-pterygoid bones, in *Mylostoma* there were certainly several pairs of pavement teeth in the roof of the mouth. The spatulate bones which form the supports of the principal dental plates of the lower jaw evidently represent the thin, flattened, smooth, and once buried posterior end of the dentary bone [= splenial] in all of the Dinichthidae."

The earliest effort to trace homologies between the dentition of Mylostoma and Dinichthys is that of Bashford Dean, in 1901. Relying upon analogy with Dinichthys, he assumed that the upper dentition of Mylostoma must have been limited to two pairs of plates only; and finding that number to be present in the nearly complete example of *M. variabile* studied by him, he concluded that one of these pairs must correspond to the so-called "premaxillary" element, and the other to the so-called "maxillary" or "shear-tooth" of Dinichthys. Apparently the possibility did not occur to him that the two pairs of

[1] *Loc. cit.* (1889), p. 162.

tritoral plates in Mylostoma might together be equivalent to the single "maxillary" element, as it is commonly called in Dinichthys, and that a third pair of upper dental plates representing the "premaxillaries" were either actually or potentially present in Mylostoma. At all events greater weight was placed upon assumed numerical correspondence of dental plates in the two genera than upon morphological equivalence, for it is impossible to recognize the least similitude in form between the usual Arthrodiran "premaxillary" and either of the tabular crushing plates of Mylostoma. Denying that Arthrodires belong to Pisces proper, and that they have gill-arch jaws, he holds that their dental apparatus is non-homologous with that of all other fishes.

According to the present writer's interpretation, the two pairs of Mylostomid palatal plates are together equivalent to the single pair of "maxillary" elements in the Coccosteid type of dentition, this latter being regarded merely as a modification of the Mylostomid, adapted for cutting instead of crushing. That the upper dentition of Mylostoma consists in all of three pairs of plates, the foremost of which is the precise morphological equivalent of the so-called "premaxillary" pair in Dinichthys, is to be inferred not only from analogy with Dinomylostoma, in which this number has been definitely proved to obtain,[1] but from the remarkable constancy of form displayed by the more forwardly placed element in all Arthrodiran genera where it is known to occur. Unacquainted though we be with actual specimens, the existence of vomerine teeth in Mylostoma, real or potential, is an assured fact.

It follows from the point of view just stated that the Mylostomid and Dinichthyid types of dentition are reducible to a common plan, and this plan is further seen to be identical with that found in Dipnoans. The one element which by virtue of its function retains a constant form among Coccosteans generally, and in at least one genus of Mylostomids, is that commonly known as the "premaxillary," in reality the *vomerine* tooth; and the palatal plates (or more properly the palato-pterygoids) of the more primitive Mylostomid type are seen to have become fused, turned upright, and sharpened into a cutting edge along their functional margin in the more specialized Dinichthyid type.

[1] The recently published suggestion on the part of Dr. Hussakof (Mem. Amer. Mus. Nat. Hist. 1906, **9**, p. 119) that the type of *Dinomylostoma beecheri* includes portions of more than one individual, all embedded in a single block of shale, is now abandoned by that writer as the result of further study of the original material. This statement is made here with Dr. Hussakof's consent.

The Mylostomid is properly regarded as the more primitive type of dentition on account of its obvious agreement with the Ceratodont, a fact previously noted by Newberry. And indeed, as he rightly observed, their resemblance is such as "will strike any one who examines them, and no closer analogy suggests itself in the whole range of ichthyic dentition." The combined evidence of dental, cranial, and most of the skeletal characters (the only marked exception being that of dermal armoring) furnishes wellnigh irresistible proof of the Dipnoan affinities of Arthrodires. A close parallel exists between the dentition of Mylostoma and Ceratodonts on the one hand, and Dinichthys and Protopterus on the other. The coincidence ceases to be remarkable when it is understood that other facts as well point to a common origin for Ceratodonts and Arthrodires. Very interesting also is Semon's observation that in the young of Neoceratodus the upper dental plates are at first divided into two pairs, as in Mylostomids, these afterwards combining into a single pair of palato-pterygoids.[1]

Adopting the view that the Arthrodiran type of dentition is strictly homologous with the Dipnoan, it is desirable to employ uniform designations for the dental parts. The tooth usually called "premaxillary" in the former group is therefore to be identified with the *vomerine* of typical Dipnoans, and the one or two succeeding pairs of "maxillaries" as the case may be, with the *palato-pterygoid* dental plates. The latter may be supposed to have been supported by the palato-pterygoid cartilage in Mylostoma precisely in the same manner as in Ceratodonts and Ctenodipterines. Their homologues in Dinichthys were no doubt situated well within the interior of the headshield, as we have a right to expect, at least, from analogy with Mylostoma. Some device is evidently required, owing to their large size, to take up the strains due to impact against the powerful lower dentition, and this we find actually provided for by the massive ridges developed on the under side of the headshield, whose position, direction, and inferred function suggest comparison with similar ridges in Neoceratodus.

Conclusions. — The consequences depending upon Dean's reconstruction of the Mylostomid dentition are as follows: The complete upper dentition of Mylostoma consists of two pairs of tritoral plates only, one of which is the functional, but not the morphological equivalent of the

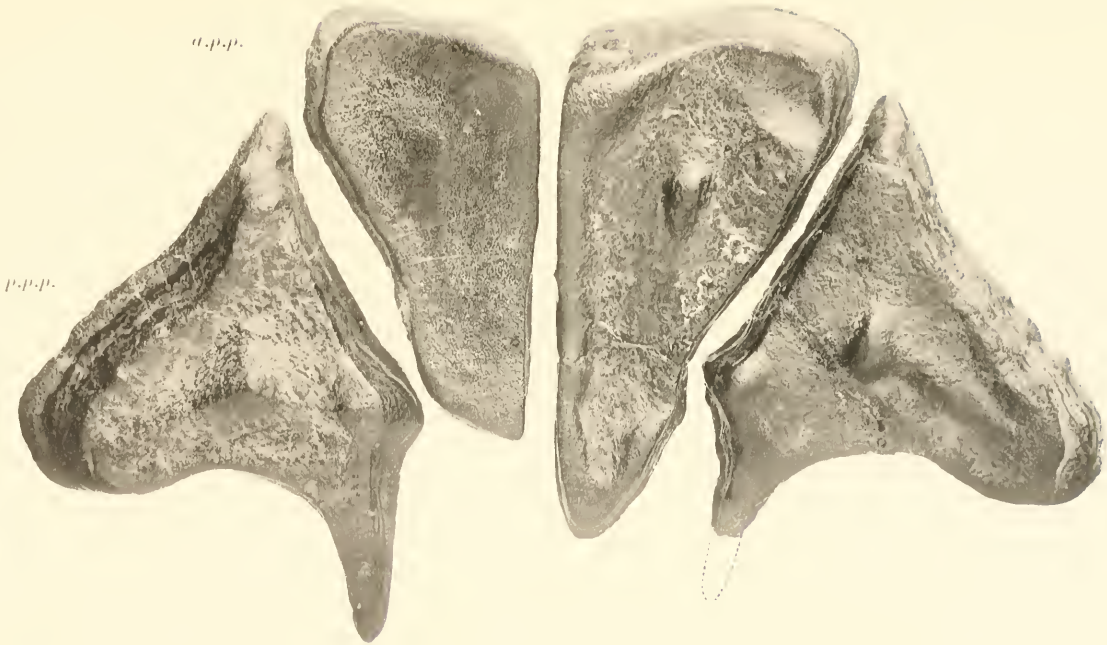
[1] Consult in this connection the recently published conclusions of Prof. J. Graham Kerr on the genetic affinities of lower Gnathostomata, in his paper entitled Embryology of certain of the lower Fishes, and its bearing upon Vertebrate Morphology. Proc. Roy. Phys. Soc. Edinb. 1906, **16**, pp. 191-215.

"premaxillary" teeth in Dinichthys, and the other of the so-called "maxillary" or "shear-teeth." The hypothesis of an additional paired element in advance of these two, itself representing the "premaxillary" in Dinichthys, is not considered in the case of Mylostoma, and rejected in the case of Dinomylostoma. The tritoral plates are arranged in such manner that the mandibles cannot close against them directly so as to produce the observed marks of contact without operating by rotary movements, and without being capable of approximation and separation at their anterior extremities, — conditions which are unparalleled among Chordates. All the jaw-parts are regarded as of purely dermal origin, and therefore non-homologous with those of ordinary fishes. Their alleged structural differences, and assumed functional differences, make it necessary to exclude Arthrodires from fishes proper.

The consequences depending upon the newer reconstruction of the same materials are that all known Dinichthyids and at least one Mylostomid have a similar form of "premaxillary," which is the exact homologue of the vomerine teeth in Dipnoans, and that the succeeding pair or pairs (when two are present) of trenchant or crushing plates are homologous with the palato-pterygoid dental plates of typical Dipneusti. The jaws operate in the usual manner, are of the normal gill-arch type, and exhibit precisely the same conformation as those belonging to autostylic fishes. The combined evidence of the majority of characters of Arthrodires proves that they are specialized Dipnoans.

EXPLANATION OF PLATE.

Upper pavement dentition of *Mylostoma variabile* Newberry, from the Cleveland shale of Sheffield, Ohio. × $\frac{1}{1}$. *a.p.p.*, anterior pair of palatopterygoid plates: *right* (Amer. Mus. Nat. Hist., Cat. 43 G), *left* (*idem*, 42 G). *p.p.p.*, posterior palatopterygoid plates: *right* (Amer. Mus. Nat. Hist. Cat. 3591), *left* (Mus. Comp. Zool. Cat. 1437). Specimens belonging to different individuals, rearranged in their inferred natural position.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Bulletin of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. L. No. 8.

PRELIMINARY REPORT ON THE ECHINI COLLECTED, IN 1902, AMONG THE HAWAIIAN ISLANDS, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," IN CHARGE OF COMMANDER CHAUNCEY THOMAS, U. S. N., COMMANDING.

By Alexander Agassiz and Hubert Lyman Clark.

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No. 8. — *Preliminary Report on the Echini collected, in* 1902, *among the Hawaiian Islands, by the U. S. Fish Commission Steamer "Albatross," in charge of* Commander Chauncey Thomas, U. S. N., *Commanding. By* Alexander Agassiz *and* Hubert Lyman Clark.

The collection of Echini made by the U. S. F. C. S. "Albatross" in the spring of 1902 among the Hawaiian Islands is a very extensive one. A preliminary examination shows it to contain no less than 2,450 specimens distributed among 49 genera five of which are new, and 67 species of which 36 are new. It was hoped that the collection would extend to sufficient depths to show the connection of an oceanic insular fauna with the surrounding abyssal region. Unfortunately, as in the case of the Hawaiian starfishes,[1] the depths from which Echini were collected by the "Albatross" did not extend much beyond 500 fathoms. Of the 126 stations from which starfishes were obtained, only 11 were in depths greater than 500 fathoms; and of the 180 stations from which Echini were collected, only 14 were in greater depths than 500 fathoms; so that as regards these two groups of Echinoderms, the collections can only be considered as representing the fauna of the Hawaiian slopes to a depth of about 500 fathoms, and that at a comparatively short distance from the shore, the 1000-fathom line rarely being more than 20 miles, usually eight to ten miles, distant, and frequently, as around Hawaii,[2] much less. The species, therefore, naturally belong to what has been called the Continental fauna in an analysis of the known Echini prepared for the "Challenger" reports.[3] No dredgings containing Echini were made beyond 1278 fathoms, and none of the typical deep sea Echini already known from the Central Pacific, from the Panamic district, and from the tropical regions of the Eastern Pacific were collected.

The following species were recorded from the Hawaiian Islands previous to the visit of the "Albatross." Those which are not in the present

[1] The Starfishes of the Hawaiian Islands. By Walter K. Fisher. Bull. U. S. Fish Com. Vol. **23**, Part 3, p. 989. 1906.

[2] See Chart of the U. S. Hydrographic Office, No. 1368.

[3] The Voyage of H. M. S. "Challenger." Report on the Echinoidea, by Alexander Agassiz, p. 222, 232–237, 1881.

collection are marked with an *, and the name of the collection, in which there is a specimen from the Hawaiian Islands, follows in parentheses.

Cidaris metularia Bl.
Chondrocidaris gigantea A. Ag.
* Phyllacanthus verticillata A. Ag. (Mus. Godef.).
Diadema setosum (probably = *paucispinum* of this list).
* Echinothrix Desorii Pet. (M. C. Z.)
Echinothrix diadema Linné.
* Astropyga pulvinata Agass. ("Challenger").
Colobocentrotus atratus Br. (probably = *Quoyi* of this list).
Heterocentrotus mammillatus Br.
* Heterocentrotus trigonarius Br. (M. C. Z.).
Echinometra lucunter Bl. (= *Mathaei* of this list).
Echinometra oblonga Bl.
* Strongylocentrotus nudus A. Ag. (M. C. Z.).
* Pseudoboletia granulata A. Ag. (M. C. Z.).
Echinostrephus molare A. Ag.
* Mespilia globulosus Agass. (Mus. Godef.).
* Toxopneustes pileolus Agass. ("Challenger").
Hipponoë variegata A. Ag.
Fibularia australis Desml.
* Echinanthus testudinarius Gray (Breslau Mus.).
* Lovenia subcarinata Gray (Stockholm Mus.).
Brissus carinatus Gray.
Metalia maculosa A. Ag.
* Metalia sternalis Gray (M. C. Z.).
* Faorina chinensis Gray (M. C. Z.).

Of these 25 species it will be seen that 13 were collected by the "Albatross" in 1902. This is in noticeable contrast to the Hawaiian collection of starfishes, of which Dr. Fisher reports that only one of the ten species formerly known from the islands was dredged by the "Albatross." The absence of 12 of the previously recorded Echini is not surprising, as the collections hitherto have been made, with few exceptions, from along shore, while the collections made by the "Albatross" in 1902 were from off the shores to deep water. The bathymetrical range of several species is greatly extended, and a few Indo-Pacific species are added to the Hawaiian fauna, which now includes 79 species of Echini.

As regards the geographical relations of the Echini collected, it is interesting to note that of the new species of Cidaridae two are related to the Panamic fauna, the others to the Pacific or Indo-Pacific. The Salenias are Panamic, while the Aspidodiadematidae and many of the Diadematidae are Indo-Pacific. In the Echinothuridae we find *Phormosoma*

bursarium, an East Indian form, and Sperosoma, Indo-Pacific and Atlantic. The occurrence of a new species of Hemipedina is interesting, as well as that of Temnopleuridae of Indo-Pacific affinities, while none of the allied Australian genera have been collected. The number of interesting Clypeastroids collected is remarkable. Several of them are identical with or closely allied to, the Clypeastroids collected by the "Siboga" in the East Indian Archipelago, so that in this group the collection is typically Indo-Pacific. The peculiar Laganidae are East Indian and Japanese. A new genus of the closely circumscribed family of Echinoneidae, from shallow water, is an important addition to the Pacific Fauna.

A fair number of interesting Spatangoids were brought to light, though the dredgings did not extend to depths great enough to include the zone of the Urechinidae, Cystechinidae, and the like. Three genera of Palaeopneustidae were obtained, Phrissocystis, Meijerea, and a new genus (Pycnolampas) allied to Homolampas. The first two show affinities with the Panamic and East Indian echinid faunae and Pycnolampas with a Pacific and Atlantic type. Among the Spatangina are two species of Gymnopatagus, suggesting East Indian affinities, and two Loveniae, the one with East Indian the other with Panamic relations. A new Rhinobrissus and several species of Brissopsis are allied to East Indian and Pacific types. We may also mention the existence in the collection of two species of Aceste thus far known only from the dredgings of the "Challenger" in the Atlantic and Pacific, and the "Siboga" among the East Indian islands, at depths of 620 to 2600 fathoms. The Hawaiian species range only from 238 to 284 fathoms. Finally there is a fragment of a species of Periaster which must have been of gigantic size among the species of the genus.

DESMOSTICHA Haeckel

CIDARIDAE Müller.

Cidaris metularia Bl.
Dorocidaris calacantha A. Ag. and Clark.
Chondrocidaris gigantea A. Ag.
Phyllacanthus Thomasii A. Ag. and Clark.
Stephanocidaris hawaiiensis A. Ag. and Clark.
Stereocidaris grandis Död.
Stereocidaris leucacantha A. Ag. and Clark.
Porocidaris variabilis A. Ag. and Clark.
Acanthocidaris hastigera A. Ag. and Clark.

Descriptions of the above species, with numerous plates, have appeared in "Hawaiian and Other Pacific Echini. The Cidaridae," Mem. M. C. Z., **34**, No. 1, February, 1907. 42 pages, 44 plates.

SALENIDAE Agass.

Salenia miliaris A. Ag.

Salenia miliaris A. Agassiz, 1898. Bull. M. C. Z., **32**, No. 5, p. 74; Plate 2, Figs. 2–4.

Small specimens of this Panamic species were collected at the following stations.

Station 4060. Off Alia Point Light, N. E. coast of Hawaii, 759–913 fathoms.
" 4125. Off Kahuku Point, Oahu, 963–1124 fathoms.
" 4181. Off Hanamaulu, Kauai, 671–811 fathoms.

Four specimens.

Salenia crassispina A. Ag. and Clark.

This species, although closely related to the preceding, is easily distinguished by the primary radioles which are remarkably stout, and although distinctly verticillate, are quite smooth. In *miliaris*, the greatest thickness of a radiole is much less than the diameter of its milled ring, while in *crassispina* the diameter of the spine is fully equal to, and may exceed that of its milled ring. The species is further remarkable for the comparatively slight depth at which it was taken.

Station 4045. Off Kawaihae Light, W. coast of Hawaii, 147–198 fathoms.

One specimen.

ARBACIADAE Gray.

Habrocidaris A. Ag. and Clark.

This genus is established for *Podocidaris scutata* A. Ag. of the West Indies, and for the following closely related species from the Hawaiian Islands. Although quite similar to Podocidaris A. Ag., and even more so to Pygmaeocidaris Död., it may be readily distinguished from both by the very thin and delicate test, the regular and very slightly indented actinal system, the close plating of the entire buccal membrane, and the distinctly triangular primary radioles.

Habrocidaris argentea A. Ag. and Clark.

This species is closely allied to *H. scutata* A. Ag. from Santa Cruz (580 fms.). It is at once distinguished by the much larger abactinal system, the different shape of the ocular plates, and the distinctly pentagonal actinal system. The single specimen taken is 11.5 mm. in diameter, with the abactinal system 7 mm., the anal system 2 mm., and the actinal system 6 mm. Unfortunately all the primary radioles are broken and only the basal portions of a few remain attached to the test. These radioles are triangular in cross-section and the three edges, though rounded, project conspicuously from the solid axis. The test is silvery, tinged with brown, while the primary radioles were evidently white.

Station 3973. Near French Frigate Shoal; 23° 47′ 10″ N. — 166° 24′ 55″ W.; 395–397 fathoms.

ASPIDODIADEMATIDAE Duncan.

Aspidodiadema nicobaricum Död.

Aspidodiadema nicobaricum Döderlein, 1901. Zool. Anz. Bd. **24**, p. 21.

This species was taken at many stations, and in considerable numbers. The specimens are much smaller than those described by Döderlein, as the largest is only 25 mm. in diameter, while his were 33–39 mm. There are also slight differences in color, the Hawaiian specimens being much paler.

Station 3892. Off Mokapu Islet, N. coast of Molokai, 328–414 fathoms.
" 3981. Off Nawiliwili Light, Kauai, 414–636 fathoms.
" 3988. Off Hanamaulu, Kauai, 165–469 fathoms.
" 3989. Off Hanamaulu, Kauai, 385–500 fathoms.
" 3994. Off Mokuaeae Islet, Kauai, 330–382 fathoms.
" 4013. Off Hanamaulu, Kauai, 399–419 fathoms.
" 4014. Off Hanamaulu, Kauai, 362–399 fathoms.
" 4021. Off Hanamaulu, Kauai, 286–399 fathoms.
" 4022. Off Hanamaulu, Kauai, 374–399 fathoms.
" 4025. Off Mokuaeae Point, Kauai, 275–368 fathoms.
" 4030. Off Ukula Point, Kauai, 423–438 fathoms.
" 4107. Off Lae-o Ka Laau Light, Molokai, 350–355 fathoms.
" 4110. Off Lae-o Ka Laau Light, Molokai, 449–460 fathoms.
" 4112. Off Lae-o Ka Laau Light, Molokai, 433–447 fathoms.
" 4131. Off Hanamaulu, Kauai, 257–309 fathoms.
" 4137. Off Hanamaulu, Kauai, 411–476 fathoms.
" 4140. Off Hanamaulu, Kauai, 339–437 fathoms.
" 4141. Off Hanamaulu, Kauai, 437–632 fathoms.
" 4166. Off Modu Manu, 293–800 fathoms.
" 4177. Off Kawahioa Point, Niihau, 319–451 fathoms.
" 4180. Off Kawahioa Point, Niihau, 417–426 fathoms.
" 4187. Off Hanamaulu, Kauai, 508–703 fathoms.

The average depth at these stations is 424 fathoms and there is no reason to believe that any specimens of this species were taken in less than 300 fathoms.

One hundred and sixty-nine specimens.

Aspidodiadema meijerei A. Ag. and Clark.

Aspidodiadema nicobaricum var. *meijerei* Döderlein, 1906. Echin. Deutsch. Tiefsee-Exp., p. 165.

A large series of this form was taken by the "Albatross," and as it seems to show constant characters, we look upon it as a distinct species, although the features on which it is based are slight. Besides the striking difference in color of the primary spines, there is a slight difference in the relative size of the abactinal and anal systems. In the Hawaiian specimens of *nicobaricum*, the primary spines are very pale purplish, the actinal surface of the test tends to become deep purple,

the diameter of the abactinal system is rather more than half the diameter of the test, and the anal system is nearly three-fourths of the abactinal; while in the specimens of *meijerei*, the primary spines are bright green, the *abactinal* surface tends to become deep purple, the diameter of the abactinal system about equals one-half that of the test, and the anal system is about two-thirds of the abactinal. The specimens of *meijerei* are on the whole much larger than those of *nicobaricum*, some of them being over 30 mm. in diameter. They also come from more shallow water, and only from the vicinity of Molokai and southern Oahu, as the following list of stations shows.

Station 3817. Off Diamond Head, Oahu, 320 fathoms.
" 3818. Off Diamond Head, Oahu, 293–295 fathoms.
" 3836. Off Lae-o Ka Laau Light, Molokai, 238–255 fathoms.
" 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 3865. Off Mokuhooniki Islet, Pailolo Channel, 256 fathoms.
" 3914. Off Diamond Head, Oahu, 289–292 fathoms.
" 3918. Off Diamond Head, Oahu, 257–294 fathoms.
" 3920. Off Diamond Head, Oahu, 265–280 fathoms.
" 4096. Off Mokuhooniki Islet, Pailolo Channel, 272–286 fathoms.
" 4097. Off Mokuhooniki Islet, Pailolo Channel, 286 fathoms.
" 4105. Off Lae-o Ka Laau Light, Molokai, 314–335 fathoms.
" 4116. Off Kahuku Point, Oahu, 241–282 fathoms.
" 4122. Off Barber's Point Light, Oahu, 192–352 fathoms.
" 4178 (?). Off Kawahioa Point, Niihau, 319–378 fathoms.

The average depth of these stations is 280 fathoms, and there is no reason to believe that any specimens of this species were taken in more than 320 fathoms.

One hundred and forty-four specimens.

DIADEMATIDAE Peters.

Diadema paucispinum A. Ag.

Diadema paucispinum A. Agassiz, 1863, Bull. M. C. Z., **1**, p. 19.

These specimens are certainly distinct from West Indian specimens and equally so from *mexicanum* and *savignyi*; it therefore seems advisable to recognize *paucispinum* once more.

Puako Bay, Hawaii.
Honolulu.
Station 3968. French Frigate Shoal, 14½–16½ fathoms
" 4169. Off Modu Manu, 21–22 fathoms.

Nine specimens.

Echinothrix calamaris A. Ag.

Echinus calamaris Pallas, 1774. Spic. Zool. **1**, fasc. 10, p. 31; Plate 2, Figs. 4–8.
Echinothrix calamaris A. Agassiz, 1872. Rev. Ech. Pt. 1, p. 119.

Only young specimens were collected, the largest being 30 mm. in diameter.
Puako Bay, Hawaii.

Station 4033. Penguin Bank, S. coast of Oahu, 28–29 fathoms.
Two specimens.

Echinothrix turcarum Pet.

Diadema turcarum Schynvien, 1711. Thes. Imag., p. 2; Plate 14, Fig. B.
Echinothrix turcarum Peters, 1853. Monatsb. Akad. Berlin, p. 484.

A good series of adults and young, ranging from 25 to 80 mm. in diameter, was taken at Puako Bay, Hawaii, and at Honolulu.
Twelve specimens.

Astropyga radiata Gray.

Cidaris radiata Leske, 1778. Klein Nat. dis. Ech., p. 116; Plate 44, Fig. 1.
Astropyga radiata Gray, 1825. Ann. Phil. **10**, p. 2.
Only a single very small specimen (diameter, 26 mm.) is in the collection.
Station 3875. Auau Channel, between Maui and Lanai, 34–65 fathoms.

Centrostephanus asteriscus A. Ag. and Clark.

This very pretty little species is easily distinguished from other members of the genus by the large number of coronal plates and the peculiar abactinal system. In a specimen only 3.5 mm. in diameter there are already eight coronal plates, while an individual 14 mm. in diameter has 13. The ocular plates are small and nearly or quite excluded from the medium-sized anal system, which is closely covered with very small plates. The oculars are more completely excluded in the larger specimen than in the smaller ones. The genital pores are conspicuous. The buccal plates carry spines as well as pedicellariae. The color is light reddish, becoming reddish-white actinally, and the primary radioles are prettily banded with red and whitish; from the end of each ambulacrum a conspicuous white line runs straight to the centre of the anal system, the five lines forming a conspicuous star on the red abactinal surface; the lines are broadest in the smallest specimen and become narrower (relatively) with age. The largest specimen taken has the test 14 mm. in diameter and 6.25 mm. high, the abactinal system 5.5 mm., and the actinal system 6 mm. The primary radioles, the longest of which measure 20 mm., are provided with rather widely spaced whorls of very minute, sharp spinelets.

Station 4034. Penguin Bank, S. coast of Oahu, 14–28 fathoms.
" 4066. Off Ka Lae-o Ka Ilio Point, Maui, 49–176 fathoms.
" 4128. Off Hanamaulu, Kauai, 68–253 fathoms.
" 4161. Off Modu Manu, 39–183 fathoms.
" 4163. Off Modu Manu, 24–40 fathoms.
Five specimens.

Chaetodiadema pallidum A. Ag. and Clark.

Of this interesting genus, a handsome new species proves to be common in certain localities among the Hawaiian Islands. It is sharply distinguished from the

two species hitherto known by the coloration, which is pale buff above when dry, more or less tinged with purple when wet, becoming buffy-white beneath. The sides of the bare interambulacral areas on the abactinal surface are more or less distinctly yellow; in many specimens the ambulacral edge of this area is marked by a broad, dull red line extending from the ambitus to the genital plate, but these lines may be interrupted and in about half the specimens are entirely wanting. On the actinal side, some individuals have a deep brown line forming a more or less perfect pentagon around the actinostome, about one-third of the distance to the ambitus. The primary radioles are slender, of moderate but variable length, the longest equalling the diameter of the test, and are decidedly flattened. They are nearly white, but many have a purplish longitudinal stripe on the abactinal side, and not infrequently they are handsomely banded with purple. There is no blue anywhere on test or spines. The tuberculation of the test is more like that of *granulosum* than of *japonicum*, but there are only eight series of primary interambulacral tubercles at the ambitus even in the largest individuals. The specimens range in diameter from 42 to 70 mm. The test is very flat, the height being only .25–.30 of the diameter. The abactinal system is .30–.42 and the actinal only .17–.24 of the diameter, while the anal system is .60–.65 of the abactinal. The test is relatively higher and the abactinal and actinal systems larger in small than in large individuals.

Station 3856. Pailolo Channel, between Maui and Molokai, 127 fathoms.
" 3857. Pailolo Channel, between Maui and Molokai, 127–128 fathoms.
" 3957. Vicinity of Laysan Island, 173–220 fathoms.
" 4103. Pailolo Channel, between Maui and Molokai, 132–141 fathoms.
" 4104. Pailolo Channel, between Maui and Molokai, 123–141 fathoms.

Eighty-two specimens.

Leptodiadema A. Ag. and Clark.

This genus is established for a very small Diadematoid, which is apparently quite different from any known genus. The size, form, and spines remind one of Lissodiadema and the abactinal system is not altogether unlike that genus, but the tuberculation is entirely different. Test flattened, both abactinally and actinally. Ambulacra narrow, with pores in single straight series, not becoming crowded at actinostome. Each ambulacrum carries a double series of primary tubercles, extending from abactinal system to actinostome. Coronal plates numerous (13–14 in specimen 9 mm. in diameter), each with a large primary tubercle, at outer end. Below the ambitus, these tubercles are increasingly nearer centre of plate, so that the two series of them converge and meet in a point at actinostome. Beginning with the fifth (from abactinal system), each coronal plate carries a second somewhat smaller tubercle, at inner end, and these two series terminate about four plates from actinostome. Secondary spines few; miliaries almost wanting. Primary tubercles, low, perforate, apparently finely crenulate, those of the ambulacra smaller than those of the interambulacra. Abactinal system moderate, with oculars on each side of madreporic plate excluded

from anal system; other oculars narrowly in contact with the single series of large anal plates. Genital openings of only moderate size. Anal papilla conspicuous. Actinostome somewhat larger than abactinal system; actinal cuts slight. Buccal membrane closely covered with plates as in young Diadema. Primaries delicate, glassy, slightly curved, blunt, with 5–7 prominent ridges, bearing few scattered, very slender teeth, about equal to half the diameter of the test; those of the ambulacra scarcely shorter or more slender than the others.

Leptodiadema purpureum A. Ag. and Clark.

The single specimen is only 9 mm. in diameter. The color is dull purplish, becoming bright purple on the buccal membrane. The spines are nearly colorless.

Station 3847. Off Lae-o Ka Laau Light, Molokai, 23–24 fathoms.

ECHINOTHURIDAE Wyv. Thoms.

Phormosoma bursarium A. Ag.

Phormosoma bursarium A. Agassiz, 1881. Rep. Chall. Ech. p. 99; Plate 10 b.

An excellent series of this species, ranging from 23 to 110 mm. in diameter, was taken at the following stations.

Station 3884. Pailolo Channel, between Maui and Molokai, 284–290 fathoms.
" 3892. Off Mokapu Islet, N. coast of Molokai, 328–414 fathoms.
" 3904. Off Mokapu Islet, N. coast of Molokai, 295 fathoms.
" 3957. Off Laysan Island, 173–220 fathoms.
" 3988. Off Hanamaulu, Kauai, 165–469 fathoms.
" 3994. Off Mokuaeae Islet, Kauai, 330–382 fathoms.
" 3997. Off Ukula Point, Kauai, 418–429 fathoms.
" 4019. Off Hanamaulu, Kauai, 409–550 fathoms.
" 4022. Off Hanamaulu, Kauai, 374–399 fathoms.
" 4025. Off Mokuaeae Point, Kauai, 275–368 fathoms.
" 4087. Off Mokuhooniki Islet, Pailolo Channel, 306–308 fathoms.
" 4089. Off Mokuhooniki Islet, Pailolo Channel, 297–304 fathoms.
" 4091. Off Mokuhooniki Islet, Pailolo Channel, 306–308 fathoms.
" 4110. Off Lae-o Ka Laau Light, Molokai, 449–460 fathoms.
" 4111. Off Lae-o Ka Laau Light, Molokai, 460–470 fathoms.
" 4112. Off Lae-o Ka Laau Light, Molokai, 433–447 fathoms.
" 4113. Off Lae-o Ka Laau Light, Molokai, 395–433 fathoms.
" 4141. Off Hanamaulu, Kauai, 437–632 fathoms.

One hundred and fifty-four specimens.

Sperosoma obscurum A. Ag. and Clark.

The large series of Sperosomas collected cannot be referred to any of the previously known species. The coloration is somewhat variable, for while most of the specimens are more or less decidedly violet or purple, some large ones are distinctly gray or yellowish-brown. The plates are not outlined in white (as in the

other species) but are frequently quite plainly outlined in some shade *darker* than the test, though they are often very indistinct. The ambulacral and interambulacral areas are nearly equal in width at the ambitus but the interambulacra may be somewhat broader. The pores on the abactinal surface are arranged in a double series on each side of the ambulacrum but the *outer* series contains fifty per cent more pores than the inner, and a quincunx arrangement is seldom visible. There are very few large tubercles on the abactinal surface (about 35 in the largest specimen), and relatively few actinally; the latter are confined to the plates near the ambitus. The greater part of the actinal surface, especially about the actinostome, is closely covered with small tubercles of more or less uniform size, giving an appearance not wholly unlike *Chaetodiadema*; this is most marked in large individuals. The specimens taken range from 20 to 220 mm. in diameter.

Station 3824. Off Lae-o Ka Laau Light, Molokai, 222–498 fathoms.
" 3865. Pailolo Channel, between Maui and Molokai, 256–283 fathoms.
" 3979. Off Modu Manu, 222–387 fathoms.
" 3988. Off Hanamaulu, Kauai, 165–469 fathoms.
" 4015. Off Hanamaulu, Kauai, 318–362 fathoms.
" 4021. Off Hanamaulu, Kauai, 286–399 fathoms.
" 4025. Off Mokuaeae Point, Kauai, 275–368 fathoms.
" 4036. Off Kawaihae Light, W. coast of Hawaii, 687–692 fathoms.
" 4089. Off Mokuhooniki Islet, Pailolo Channel, 297–306 fathoms.
" 4096. Off Mokuhooniki Islet, Pailolo Channel, 272–286 fathoms.
" 4112. Off Lae-o Ka Laau Light, Molokai, 433–447 fathoms.
" 4117. Off Kahuku Point, Oahu, 253–282 fathoms.
" 4130. Off Hanamaulu, Kauai, 283–309 fathoms.
" 4131. Off Hanamaulu, Kauai, 257–309 fathoms.
" 4134. Off Hanamaulu, Kauai, 225–324 fathoms.
" 4136. Off Hanamaulu, Kauai, 294–352 fathoms.
" 4137. Off Hanamaulu, Kauai, 411–476 fathoms.

Thirty-nine specimens.

ECHINOMETRIDAE Gray.

Heterocentrotus mammillatus Br.

Cidaris mammillata Klein, 1734. Nat. disp. Ech. p. 19; Plate 6, Figs. A, B.
Heterocentrotus mammillatus Brandt, 1835. Prod. Desc. Anim., p. 266.

All the specimens of Heterocentrotus in the collection are referable to this species.

Laysan Island, and Puako Bay, Hawaii.

Twenty-four specimens.

Colobocentrotus Quoyi Br.

Echinus Quoy de Blainville, 1825. Dict. Sci. Nat. **37**, p. 96.
Colobocentrotus Quoyi Brandt, 1835. Prod. Desc. Anim., p. 267.

A large series of Colobocentrotus was taken but all are referable to this single species, and show little variation.

Necker Island.
Lanai Island.
Puako Bay, Hawaii.
Kamalino Bay, Niihau.
Napeli, Maui.
One hundred and three specimens.

Echinometra Mathaei Bl.

Echinus Mathaei de Blainville, 1825. Dict. Sci. Nat., **37**, p. 94.
Echinometra Mathaei de Blainville, 1834. Man. d'Actin., p. 225.

The series of Echinometras is quite easily divisible into two sets, one of which consists of individuals with high, usually elongated tests, large tubercles, stout spines and relatively small (.17–.23 of long diameter) abactinal system. These are evidently the wide-ranging and common *Mathaei* (formerly called *lucunter*).

Honolulu reefs.
Kamalino Bay, Niihau.
Laysan Island.
Station 3959. Off Laysan Island, 10 fathoms.
Thirteen specimens.

Echinometra picta A. Ag. and Clark.

The other set of Echinometras has the test much flatter, the height rarely over .50 of the long diameter, the abactinal system larger (.24–.30 of the long diameter), the tubercles smaller, giving the abactinal surface a much more bare appearance than in *Mathaei*, and the spines longer and more slender. These two forms are not sharply set off from each other, but there are few individuals which cannot be distinguished at a glance, and it seems desirable to give the flat individuals a name. Similar specimens are in the Museum collection from the Society Islands, but not from the East Indies, or west thereof. This species seems to bear the same relation to *Mathaei* that *viridis* of the West Indies does to *lucunter* (formerly called *subangularis*).

Honolulu reefs.
Puako Bay, Hawaii.
Necker Island.
Kamalino Bay, Niihau.
Napeli, Maui.
Station 3975. Off Necker Island Shoal, 16–171 fathoms.
Twenty-nine specimens.

Echinometra oblonga Bl.

Echinus oblongus de Blainville, 1825. Dict. Sci. Nat., **37**, p. 95.
Echinometra oblonga de Blainville, 1834. Man. d'Actin., p. 225.

A good series of this species was taken, none of which show the least approach to *mathaei* or afford the slightest difficulty in identification, without reference to the spicules in the pedicels! (vide de Meijere, 1904, and Döderlein, 1906).

Puako Bay, Hawaii.
Honolulu reefs.
Lanai Island.
Necker Island.
Hanalei, Kaui.
Kamalino Bay, Niihau.
Laysan Island.
Thirty-eight specimens.

Echinostrephus molare A. Ag.

Echinus molaris de Blainville, 1825. Dict. Sci. Nat. **37**, p. 88.
Echinostrephus molare A. Agassiz, 1872. Rev. Ech. Plate 1, p. 119.

A good series of this species is in the collection.
Laysan Island.
Station 3959. Off Laysan Island, 10 fathoms.
" 3960. Off Laysan Island, 10–19 fathoms.
" 3968. French Frigate shoal, 14½–16½ fathoms.
" 3969. French Frigate Shoal, 15–16 fathoms.
" 3970. French Frigate Shoal, 17–17½ fathoms.
" 3975. Off Necker Island Shoal, 16–171 fathoms.
" 4147. Off Modu Manu, 26 fathoms.
Twenty specimens.

TEMNOPLEURIDAE Desor.

Trigonocidaris albidoides A. Ag. and Clark

This is the Pacific representative of *T. albida* of the West Indies, and is closely allied to that species. It differs in having the test less clearly and deeply sculptured, especially abactinally, and in having more spines on the abactinal system. But the most obvious differences are in coloration: adult West Indian specimens have the abactinal system, especially the genital plates, and many of the primary tubercles very decidedly reddish, while the primary spines are pure white; the Hawaiian specimens have no trace of red on the test or tubercles, but some or all of the primaries, especially actinally, are distinctly banded or tipped with red. Of course young specimens (under 4 mm.) do not show these differences, but in adults they are quite evident. The specimen in the "Siboga" collection which had orange-banded spines, referred by de Meijere with some hesitation to *albida*, is evidently the Pacific form.

Station 3859. Off Mokuhooniki Islet, Pailolo Channel, 138–140 fathoms
" 3863. Off Mokuhooniki Islet, Pailolo Channel, 127–154 fathoms.
" 3892. Off Mokapu Islet, N. coast of Molokai, 328–414 fathoms.
" 4045. Off Kawaihae Light, W. coast of Hawaii, 147–198 fathoms.
Five specimens.

Orechinus monolini Död.

Trigonocidaris monolini A. Agassiz, 1879. Proc. Amer. Acad., **14**, p. 203.
Orechinus monolini Döderlein, 1905. Zool. Anz., **28**, p. 622.

An excellent series of this rare and interesting species was taken by the "Albatross." It is notable for the large size of many of the specimens, which range from 6 to 22 mm. in diameter.

Station 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 3865. Off Mokuhooniki Islet, Pailolo Channel, 256–283 fathoms.
" 3914. Off Diamond Head, Oahu, 289–292 fathoms.
" 3918. Off Diamond Head, Oahu, 257–294 fathoms.
" 4085. Off Puniawa Point, Maui, 267–283 fathoms.
" 4117. Off Kahuku Point, Oahu, 253–282 fathoms.
" 4125. Off Kahuku Point, Oahu, 963–1124 fathoms.
" 4126. Off Kahuku Point, Oahu, 743–1278 fathoms.
" 4131. Off Hanamaulu, Kauai, 257–309 fathoms.

Twenty-nine specimens.

Prionechinus chuni Död.

Prionechinus chuni Döderlein, 1906. Ech. Deuts. Tiefsee Exp., p. 192; Plate 24, Fig. 3.

A small, but very good, series of this interesting little urchin, ranging from 2.5 to 11 mm. in diameter, was taken at the following station. Döderlein's admirable description, coupled with the photographs he gives, leaves no doubt as to the identity of these specimens.

Station 4126. Off Kahuku Point, Oahu, 743–1278 fathoms.

Seven specimens.

Prionechinus sculptus A. Ag. and Clark.

This species is distinguished from the four previously known species of the genus, as limited by Döderlein (1906), by the very small and distinct buccal plates, with five pairs of buccal feet, the smooth, longitudinally striated primary spines, and the handsomely sculptured and ornamented abactinal system. The genital opening is near the centre of the plate. The test is not so high as in the preceding species and the anal plates, are much less numerous, with one evidently larger than the rest. The color is dull purplish-red, very pale in the smaller specimens. The primaries are white, but the longitudinal striations are purplish. The specimens range from 2 to 10 mm. in diameter.

Station 3818. Off Diamond Head, Oahu, 293–295 fathoms.
" 4028. Off Ukula Point, Kauai, 444–478 fathoms.
" 4039. Off Kawaihae Light, Hawaii, 670–697 fathoms.
" 4083. Off Puniawa Point, Maui, 238–253 fathoms.
" 4086. Off Puniawa Point, Maui, 283–308 fathoms.
" 4087. Off Mokuhooniki Islet, Pailolo Channel, 306–308 fathoms.
" 4088. Off Mokuhooniki Islet, Pailolo Channel, 297–306 fathoms.
" 4115. Off Kahuku Point, Oahu, 195–241 fathoms.

Sixty-seven specimens.

Prionechinus depressus A. Ag. and Clark.

The specimens to which we have given this name were taken with the preceding, but the larger individuals (those over 4 mm. in diameter) are so obviously different that the two are easily separated. In this species, the test is very flat and the bare, interambulacral grooves are very conspicuous. The abactinal system is entirely different from that of *P. sculptus*, as there is very little sculpturing, and the genital openings are situated at the extreme distal tip of the plates, in a groove which is continuous with the interambulacral groove. The spines, color and size are as in *sculptus*. While it is not impossible that this species and the preceding are simply the two sexes of one species, such sexual dimorphism is not at present known among the regular Echini.

Station 3818. Off Diamond Head, Oahu, 293–295 fathoms.
" 4028. Off Ukula Point, Kauai, 444–478 fathoms.
" 4083. Off Puniawa Point, Maui, 238–253 fathoms.
" 4086. Off Puniawa Point, Maui, 283–308 fathoms.
" 4088. Off Mokuhooniki Islet, Pailolo Channel, 306–308 fathoms.

Forty-five specimens.

Pleurechinus hawaiiensis A. Ag. and Clark.

Although this species is closely allied to *P. siamensis* Mortensen, it differs decidedly in color and in one or two details of structure. The abactinal interambulacral space is not at all bare, but on the other hand there are only half as many secondary and miliary tubercles on the ambulacral and interambulacral plates near the ambitus, as in the specimen of *siamensis* figured in detail by Mortensen (1904). The anal system is covered by several large plates and a few small ones, and the anus is subcentral. The color of the test is prevailingly green, with the abactinal interambulacra lighter and often pure white in striking contrast. The primaries are whitish with more or less red. The tendency towards a bright red coloration is noticeable and two specimens are almost uniformly bright red, test as well as spines. Around the actinostome the test often becomes whitish, while abactinally it is frequently marked with purplish-brown. While the color is thus very variable, there is no tendency to approach the coloration of *siamensis*, except as each species has a bright red variety.

Station 3823. Off Lae-o Ka Laau Light, Molokai, 78–222 fathoms.
" 3847. Off Lae-o Ka Laau Light, Molokai, 23–24 fathoms.
" 3871. Off Mokuhooniki Islet, Auau Channel, 13–43 fathoms.
" 3872. Off Mokuhooniki Islet, Auau Channel, 32–43 fathoms.
" 3876. Off Lahaina Light, Maui, 28–43 fathoms.
" 3962. Off Laysan Island, 16 fathoms.
" 3978. Off Modu Manu, 32–46 fathoms.
" 4148. Off Modu Manu, 26–33 fathoms.
" 4150. Off Modu Manu, 71–160 fathoms.

Sixteen specimens.

TRIPLECHINIDAE A. Ag.

Hemipedina indica de Meij.

Hemipedina indica de Meijere, 1903. Tijds. Ned. Dierk. Vereen. (2) **8**, p. 3.

The small series of this Oriental species, taken by the "Albatross," is of particular interest from the large size of most of the specimens, which range from 15 to 37 mm. They agree well with de Meijere's description, even in coloration, which shows little variation except in depth. The larger specimens have the test more flattened than the young ones, and its color is distinctly purple, while the actinostome is relatively smaller. It seems to us very unlikely that *mirabile* is a synonym of *indica*, as Döderlein now supposes.

Station 3865. Pailolo Channel, between Maui and Molokai, 256–283 fathoms.
" 3879. Off Molokini Islet, south of Lanai, 923–1081 fathoms.
" 3914. Off Diamond Head, Oahu, 289–292 fathoms.
" 4178. Off Kawahioa Point, Niihau, 319–378 fathoms.
" 4179. Off Kawahioa Point, Niihau, 378–426 fathoms.

Eleven specimens.

Hemipedina pulchella A. Ag. and Clark.

This beautiful little Echinoid may be recognized at once by the remarkable interambulacral primary radioles and the showy coloration. The test is white, becoming rosy abactinally (the ocular and genital plates of the larger specimen are quite red); the anal system is contrastingly white. The ambulacral primaries and the very few secondary spines are pure white, while the interambulacral primaries are bright yellowish-green at the base, pink in the middle, and whitish or pure white at the tip; the colors are not sharply separated, but shade into each other. The primaries of the abactinal coronal plates are one and a half times as long as the diameter of the test, or less; they are very stout (the thickness 8-10 per cent of the length) and closely resemble those of Echinometra. In the larger specimen the test is 14 mm. in diameter, and the abactinal and actinal systems each about one half as much. The anal system is remarkably small, decidedly smaller than a single genital plate, and is covered by a few (20) rounded plates. The genital opening is near the centre of the plate.

Station 3991. Off Mokuaeae Islet, Kauai, 272–296 fathoms.

Two specimens.

Psammechinus verruculatus Ltk.

Psammechinus verruculatus Lütken, 1864. Vid. Med., p. 166.

All the specimens are small, the largest being only 12 mm. in diameter, but they correspond well to de Loriol's (1883) figures and description, with the exception that the poriferous zones, on the bare test, are red or reddish, instead of greenish.

Station 3847. Off Lae-o Ka Laau Light, Molokai, 23–24 fathoms.
" 3871. Off Mokuhooniki Islet, Auau Channel, 13–43 fathoms.
" 3872. Off Mokuhooniki Islet, Auau Channel, 32–43 fathoms.
" 3955. Off Laysan Island, 20–30 fathoms.
" 3970. French Frigate Shoal, 17–17½ fathoms.
" 4031. Off Diamond Head, Oahu, 27–28 fathoms.
" 4032. Off Diamond Head, Oahu, 27–29 fathoms.
" 4149. Off Modu Manu, 33–71 fathoms.
" 4162. Off Modu Manu, 21–24 fathoms.
" 4168. Off Modu Manu, 20–21 fathoms.
Sixteen specimens.

Psammechinus paucispinus A. Ag. and Clark.

This species differs very decidedly from the preceding, and from other allied forms, in the small number of secondary and miliary spines and tubercles, and yet the abactinal interambulacra are not bare, as in *Toxopneustes semituberculatus*. The vertical sutures, especially in the interambulacra, are abactinally very distinct and somewhat depressed. There is one large primary tubercle on each ambulacral and interambulacral plate. Each ambulacral plate near the ambitus bears one secondary and two miliary tubercles and each interambulacral plate has a large secondary (or small primary) tubercle at each end and carries five or six small miliaries. The pore-pairs are in arcs of four. The abactinal system is about .33 of the diameter of the test, and only one ocular plate reaches the somewhat excentric anal system. The actinal system is more than .50 of the diameter. The test is whitish with a more or less pronounced green tinge when cleaned, while the spines vary from white to deep pink; four of the five specimens appear decidedly pink.

Station 3872. Off Mokuhooniki Islet, Auau Channel, 32–43 fathoms.
" 3876. Off Lahaina Light, Maui, 28–43 fathoms.
" 4033. Off Diamond Head, Oahu, 28–29 fathoms.
" 4164. Off Modu Manu, 40–56 fathoms.
Five specimens.

Hipponoë variegata A. Ag.

Cidaris variegata Leske, 1778. Kleins Nat. disp. Ech., p. 85.
Hipponoë variegata A. Agassiz, 1872. Rev. Ech. Plate 1, p. 135.

A good series of this variable species was obtained; the largest is 145 mm. in diameter and wholly white.

Honolulu.
Puako Bay, Hawaii.
Station 3876. Off Lahaina Light, Maui, 28–43 fathoms.
Twenty-seven specimens.

CLYPEASTRIDAE Agass.

FIBULARINA Gray.

Echinocyamus scaber de Meij.

Echinocyamus scaber de Meijere, 1903. Tijds. Ned. Dierk. Ver. (2) **8**, p. 5.

With one exception the specimens are bare tests, but all agree well with de Meijere's description and figures.

Station 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 3908. Off Diamond Head, Oahu, 304–308 fathoms.
" 3914. Off Diamond Head, Oahu, 289–292 fathoms.

Five specimens.

Fibularia australis Desml.

Fibularia australis Desmoulins, 1837. Tabl. Syn., p. 240.

With two exceptions the specimens are bare tests, and all are very small.

Station 3846. Off Lae-o Ka Laau Light, Molokai, 60–64 fathoms.
" 4045. Off Kawaihae Light, Hawaii, 147–198 fathoms.
" 4064. Off Kauhola Light, Hawaii, 63–107 fathoms.
" 4148. Off Modu Manu,, 26–33 fathoms.

Seven specimens.

ECHINANTHIDAE A. Ag.

Clypeaster scutiformis Lamk.

Echinus scutiformis Gmelin, 1788. Linn. Sys. Nat., p. 3184.
Clypeaster scutiformis Lamarck, 1816. Anim. s. Vert. **3**, p. 14.

An excellent series, ranging from 10 to 48 mm. in length, is in the collection from the following stations, and only twenty-three are bare tests.

Station 3846. Off Lae-o Ka Laau Light, Molokai, 60–64 fathoms.
" 3847. Off Lae-o Ka Laau Light, Molokai, 23–24 fathoms.
" 3848. Off Lae-o Ka Laau Light, Molokai, 44–73 fathoms.
" 3849. Off Lae-o Ka Laau Light, Molokai, 43–73 fathoms.
" 3850. Off Lae-o Ka Laau Light, Molokai, 43–66 fathoms.
" 3863. Off Mokuhooniki Islet, Pailolo Channel, 127–154 fathoms.
" 3871. Off Mokuhooniki Islet, Pailolo Channel, 13–43 fathoms.
" 3872. Off Mokuhooniki Islet, Pailolo Channel, 32–43 fathoms.
" 3874. Off Mokuhooniki Islet, Pailolo Channel, 21–28 fathoms.
" 3876. Off Lahaina Light, Maui, 28–43 fathoms.
" 3962. Off Laysan Island, 16 fathoms.
" 3982. Off Nawiliwili Light, Kauai, 233–400 (?) fathoms.
" 3987. Off Hanamaulu, Kauai, 50–55 fathoms.

Station 4031. Off Diamond Head, Oahu, 27–28 fathoms.
" 4032. Off Diamond Head, Oahu, 27–29 fathoms.
" 4033. Off Diamond Head, Oahu, 28–29 fathoms.
" 4034. Off Diamond Head, Oahu, 14–28 fathoms.
" 4061. Off Kauhola Light, Hawaii, 24–83 fathoms.
" 4128. Off Hanamaulu, Kauai, 68–253 fathoms.
" 4146. Off Modu Manu, 23–26 fathoms.
" 4148. Off Modu Manu, 26–33 fathoms.
" 4150. Off Modu Manu, 71–160 fathoms.
" 4158. Off Modu Manu, 20–30 fathoms.
" 4164. Off Modu Manu, 40–56 fathoms.

One hundred and seventy-three specimens.

Clypeaster lytopetalus A. Ag. and Clark.

This species may be recognized at once by its small size and general resemblance to *scutiformis*, combined with short, broadly obovate petals, the anterior one widely open, and with a deep groove in each ambulacrum along the median suture, extending from the abactinal system nearly to the actinostome. The tubercles are less numerous than in *scutiformis* and the primary tubercles contrast decidedly with the miliaries. The poriferous zones are exceedingly narrow (less than one millimeter in width), and are of unequal length in the lateral petals. The sutures between the abactinal plates are quite distinct. The genital openings are very small. The test is very thin and the internal structure is remarkable for the great scarcity of pillars, of which there are one or two stout ones and one or two slender ones in each interradius, nearer the actinostome than the margin of the test; there are no needle-like internal projections such as are abundant in *scutiformis*. The larger specimen (St. 3962) is 33 mm. long, 26 mm. wide and 10 mm. high. The test is decidedly arched, with a deeply sunken actinostome, and is 5 mm. thick at the margin. The odd and the posterior petals are about 11 mm. long and 5–6 mm. broad near the tip, while the anterior lateral petals are equally broad, but only 8 mm. long. The odd petal has the poriferous zones 3 mm. apart at their distal ends. The color is dark yellowish-brown. The smaller specimen is about half as large and is bright reddish-brown. It is not impossible that this species will prove to be the young of *C. excelsior* Döderlein, from Japan, but the remarkable appearance of the petals distinguishes it from the only specimen of that species yet known.

Station 3936. Off Laysan Island, 79–130 fathoms.
" 3962. Off Laysan Island, 16 fathoms.

Two specimens.

Clypeaster leptostracon A. Ag. and Clark.

This species is nearly allied to *C. virescens* Döderlein from Japan, but differs in the outline of the test, the very narrow poriferous zones, the arrangement of the

internal pillars, and the color. It also resembles somewhat, young specimens of *C. humilis*, but is readily distinguished by the narrow poriferous zones, wide open petals, and very narrow interambulacra. The test is ovate, very flat and thin, with the actinostome little sunken and the petaliferous area abruptly, but slightly, elevated. The petals are short, broadly ovate, widely open distally and with very narrow poriferous zones. There are five genital openings. The primary spines are rather long and their tubercles contrast decidedly with the not very numerous miliaries. The walls of the test are thin and there are three or four concentric series of very flat, thin vertical pillars forming interrupted walls, occupying the distal fourth of the interior, much as in Laganum. But there is also, in each interradius, as in most true Clypeasters, a group of four or five pillars near the actinostome, and there are numerous, though minute, needle-like projections on the actinal floor. The specimens range from 6 to 38 mm. in length. The largest is 31 mm. broad and 7.5 mm. high; the test is only a little more than 3 mm. thick at the margin. The petals are subequal, 9 mm. long and a trifle over 5 mm. broad, but the poriferous zones are considerably less than a millimeter in width. The posterior lateral interambulacra are less than half as wide at the ambitus as the ambulacra on either side of them, though in smaller specimens they may be three-fourths as wide. In color the specimens vary from bright yellow, or reddish-yellow, to dirty purplish-white. The yellow specimens have a large number of rather indistinct, dusky blotches on the abactinal surface. These are arranged in pairs, four pairs in each ambulacrum and interambulacrum, and form four concentric circles around the petals, parallel to the margin of the test. In all the specimens there is more or less contrast in color between the ambulacra and interambulacra on the actinal surface.

Station 3823. Off Lae-o Ka Laau Light, Molokai, 78–222 fathoms.
" 3987. Off Hanamaulu, Kauai, 50–55 fathoms.
" 4046. Off Kawaihae Light, Hawaii, 71–147 fathoms.
" 4064. Off Kauhola Light, Hawaii, 63–107 fathoms.
" 4066. Off Ka Lae-o Ka Ilio Point, Maui, 49–176 fathoms.

Fifty-seven specimens.

LAGANIDAE Des. (Emended).

Laganum fudsiyama Död.

Laganum fudsiyama Döderlein, 1885. Arch. f. Naturg. Jahrg. **51**, Bd. 1, p. 104.

A large series of this species was collected. Most of them have the superficial appearance in miniature of specimens of *Clypeaster Ravenellii* A. Ag., the centre of the test is so considerably and abruptly elevated. The amount of elevation is, however, quite variable, ranging from 25 to 40 per cent of the long diameter. The smallest specimen measures 8 × 8 mm. and the largest 50 × 46. The color is usually green, but ranges from grayish-yellow to rich, deep green. Oftentimes the ambulacra, on the actinal side, are more or less colored with dark purplish-brown.

Station 3811. Off Honolulu Light, Oahu, 52–238 fathoms.
" 3838. Off Lae-o Ka Laau Light, Molokai, 92–212 fathoms.
" 4079. Off Puniawa Point, Maui, 143–178 fathoms.
" 4080. Off Puniawa Point, Maui, 178–202 fathoms.
" 4081. Off Puniawa Point, Maui, 202–220 fathoms.
" 4115. Off Kahuku Point, Oahu, 195–241 fathoms.
" 4122. Off Barber's Point Light, Oahu, 192–352 fathoms.

Four hundred and seven specimens.

Laganum solidum de Meij.

Laganum solidum de Meijere, 1904. Ech. Siboga-Exp., p. 121; Plate 1, Figs. 64, 66.

A number of bare tests, collected at several localities, differ from both the preceding and following species, in the far more numerous primary tubercles of the abactinal surface. They answer very nearly to the description and figures of *solidum*, and may, for the present at least, be referred to that species.

Station 3811. Off Honolulu Light, Oahu, 52–238 fathoms.
" 3859. Off Mokuhooniki Islet, Pailolo Channel, 138–140 fathoms.
" 3984. Off Nawiliwili Light, Kauai, 164–237 fathoms.
" 4101. Off Mokuhooniki Islet, Pailolo Channel, 122–143 fathoms.
" 4132. Off Hanamaulu, Kauai, 257–312 fathoms.

Sixteen specimens.

Laganum strigatum A. Ag. and Clark.

This species resembles *fudsiyama* in the short, narrow, open petals, the very narrow poriferous zones, and the moderately coarse tuberculation of the test. But it is easily distinguished from that species by the flatness of the test, the height of which rarely exceeds .20 of the long diameter; the distinctly visible sutures between the plates abactinally as well as actinally; and the color, which is purplish-gray or dull brown, with the sutures more or less plainly indicated by darker lines. There are usually five, but sometimes only four, genital pores. The anal opening is near the posterior margin of the test. A typical example is 30 × 29 mm. and only 6 mm. high.

Station 3811. Off Honolulu Light, Oahu, 52–238 fathoms.
" 3814. Off Diamond Head, Oahu, 42–284 fathoms.
" 3859. Off Mokuhooniki Islet, Pailolo Channel, 138–140 fathoms.
" 3863. Off Mokuhooniki, Islet, Pailolo Channel, 127–154 fathoms.
" 3876. Off Lahaina Light, Maui, 23–43 fathoms.
" 4099. Off Puniawa Point, Maui, 152–153 fathoms.

Nine specimens.

PETALOSTICHA Haeckel.

CASSIDULIDAE Agass.

ECHINONEIDAE Agass.

Micropetalon A. Ag. and Clark.

This genus is related to Echinoneus, which it resembles quite closely superficially. It is at once distinguished from that genus by the fact that the poriferous zones are flush with the test and the pores extend only from the abactinal system about half way to the ambitus. The anterior ambulacrum has about a dozen pairs of pores in each zone; the zones of the lateral ambulacra have about 15 pairs each; and the zones of the posterior pair have about 20. The zones are very narrow, close together at the abactinal system, diverge widely to below the ambitus and then converge somewhat to the actinostome. The primary tubercles are few in number, not at all sunken into the test, and are arranged in regular vertical series. Abactinally they have definite scrobicular circles of small secondaries, but these are more or less imperfect actinally. Glassy tubercles are minute and infrequent. Abactinal system as in Echinoneus. Genital openings four. Actinostome very oblique. Anal system very large and oblique. Primary spines rather long, nearly equal to width of anal system, slender and finely striated.

Micropetalon purpureum A. Ag. and Clark.

The single specimen collected is oval, flattened both above and beneath; it is 17 mm. long, 15 mm. broad, and 8 mm. high. The actinostome is little sunken and is 6×3 mm. The anal system is 6.75×3.75 mm. The genital openings are conspicuous. On each side of each ambulacrum, close to the poriferous zone, is a vertical series of about 14 primary tubercles, which extends nearly to the actinostome, but stops several millimeters from the abactinal system. Between these two series, are two other series running from just above the ambitus nearly to the actinostome, and in the posterior ambulacra there are two more rows between the ambitus and the mouth. In each interambulacrum, there is a series of 14 or 15 tubercles on each side, extending from abactinal system to actinostome, and from two to four others extend greater or less distances above and below the ambitus. The color of the test is dirty-whitish above, becoming purple actinally; the abactinal system, poriferous zones, anal system, and actinostome are rich purple; the spines and tubercles are white.

Station 3847. Off Lae-o Ka Laau Light, Molokai, 23–24 fathoms.

SPATANGIDAE Agass.

PALEOPNEUSTIDAE A. Ag.

Phrissocystis multispina A. Ag. and Clark.

From an unknown station there are a large number of fragments of at least two, and possibly three, individuals of a species of Phrissocystis, which must have been of very large size, probably from 100–150 mm. in length. They are of a rich red-brown color and carry long spines with a reddish tinge. This species resembles *P. aculeata* A. Ag. in having no subanal fasciole and in the arrangement of the abactinal system and the ambulacra. It appears to differ from that species, not only in color, but in the much larger number of primary tubercles on the abactinal plates (8–12 instead of 4–8) and in the very large actinostome, which in one individual is 35 × 16 mm.

Meijerea excentrica A. Ag. and Clark.

This species is very similar to Phrissocystis, but has a well-developed subanal fasciole. As Döderlein (1906) has suggested, this difference necessitates a new genus which he has called Meijerea, with *Phrissocystis humilis* de Meijere as the type species. The Hawaiian specimen is evidently not *humilis*, as it is much flatter and more heart-shaped, with the abactinal system considerably posterior to the middle of the test. The subanal fasciole is also different; it encloses an open rectangular area, 4.5 mm. wide, with the base 24 mm., and the sides 10 mm. in length. The test is 74 mm. long, 60 mm. wide and only 17 mm. high, and the abactinal system is 39 mm. from the anterior edge. The color is light brown, with whitish primary spines.

Station 4039. Off Kawaihae Light, Hawaii, 670–697 fathoms.

One specimen.

Pycnolampas A. Ag. and Clark.

This genus is established for some delicate little Spatangoids, which, although apparently immature, do not appear to be the young of any known species, and seem to require a new genus for their reception. It is most nearly allied to Homolampas, but differs from that genus in the entire absence of any anterior furrow or depression, and in the subpetaloid character of the posterior ambulacra. The test is ovate, rather flat anteriorly, higher posteriorly, and is thin and fragile. There are a very few large primary spines in the anterior and lateral interambulacra, abactinally, but neither they, nor those of the actinal surface, have sunken scrobicular circles or show any pits (as in Lovenia) on the interior of the test. Abactinal system compact. Ocular plates conspicuous. Anterior ambulacrum indistinct, not at all depressed, and with few, minute pores. Poriferous zones of the other ambulacra evident, those of the posterior ambulacra especially, tending to become petaloid. Subanal and peripetalous fascioles present, distinct but narrow. No genital openings are visible.

Pycnolampas oviformis A. Ag. and Clark.

The specimens collected range from 15 to 22 mm. in longitudinal diameter. The largest is 17 mm. wide, 9 mm. high anteriorly, and 10 mm. high posteriorly. The peripetalous fasciole is nearly circular, somewhat pointed behind, 14 × 12 mm. The color is pearly white with a purplish tint on the abactinal system; the fascioles are brown and the spines are yellowish-white.

Station 3838. Off Lae-o Ka Laau Light, Molokai, 92–212 fathoms.
" 3890. Off Mokapu Islet, Molokai, 71–283 fathoms.
" 4044. Off Kawaihae Light, Hawaii, 198–233 fathoms.

Five specimens.

SPATANGINA Gray.

Spatangus paucituberculatus A. Ag. and Clark.

This species is most nearly related to *S. Lütkeni* A. Ag., but is quite different from that species. The test is very broad and flat and obliquely truncated posteriorly, sloping towards the actinostome. The groove of the anterior ambulacrum is very deep. On each side of it are a number of primary tubercles; in the lateral interambulacra the number of primary tubercles is 2, 1, or 0, and in the posterior interambulacrum there are not more than 9 or 10. The anal system is small and nearly circular. The actinal surface is much as in *Lütkeni*. The largest specimen is 78 mm. long, 74 mm. wide, and only 40 mm. high; the anterior furrow is 5 mm. deep and 13 mm. wide, at the ambitus. The color is purple, with white tubercles; primaries and secondaries silvery-white becoming purple at the base; miliary spines purple.

Station 3863. Off Mokuhooniki Islet, Pailolo Channel, 127–154 fathoms.
" 3865. Off Mokuhooniki Islet, Pailolo Channel, 256–283 fathoms.
" 4096. Off Mokuhooniki Islet, Pailolo Channel, 272–286 fathoms.
" 4097. Off Mokuhooniki Islet, Pailolo Channel, 286 fathoms.
" 4116. Off Kahuku Point, Oahu, 241–282 fathoms.

Twelve specimens.

Gymnopatagus Död.

Gymnopatagus Döderlein 1901. Zool. Anz. Bd. **23**, p. 22.

This genus was established by Döderlein for an interesting Spatangoid, taken by the "Valdivia" off the east coast of Africa, related to Eupatagus but having a decided furrow for the anterior ambulacrum. The "Albatross" has collected among the Hawaiian Islands two species of large Spatangoids, which are of special interest because they are evidently connecting links between these two genera. In one of them the anterior furrow is quite distinct, while in the other it is barely indicated, and yet the two are obviously congeneric. In both species the anterior poriferous zones of the lateral ambulacra are much narrower than the posterior zones, and are almost rudimentary near the abactinal system; a condition not

noted in either Eupatagus or Gymnopatagus. As the general appearance of these Hawaiian Spatangoids is decidedly more like Gymnopatagus than like any known species of Eupatagus, we place them for the present in the former genus, but it is an open question whether the two genera can be separated.

The Hawaiian species are of further interest from the remarkable diversity exhibited by the peripetalous fasciole, which is seldom a single, simple band. In one specimen there are several narrow but distinct fascioles across the anterior ambulacrum, within and parallel to the peripetalous fasciole. In another individual, a conspicuous branch arises from the posterior part of the fasciole and runs for several centimeters beside but slightly diverging from the main band, and finally ends abruptly. In other individuals, the lateral portions of the fasciole consist of two parallel bands, more or less connected with each other. Although the complexity of the arrangement is never as great as in *Macropneustes spatangoides* A. Ag., these fascioles at once suggest that West Indian species.

Gymnopatagus pulchellus A. Ag. and Clark.

The specimens range from 57 to 90 mm. in length. The largest is 70 mm. wide and 33 mm. high; it is widest and highest just back of the abactinal system. The anterior ambulacrum is apetaloid and scarcely sunken. There are no primary tubercles in the posterior interambulacrum but there are 35–40 in the lateral interambulacra, within the fasciole, arranged in four or five rows parallel to it; there are also about 20 similar tubercles in each of the anterior interambulacra. These tubercles carry long, slender, brownish-white spines, some of which are 30 mm. in length. The posterior petals are very long, about .40 of the length of the test. The smallest specimen is bright rose color above and nearly pure white beneath, though the spines all have a brownish cast. Larger specimens are less rosy and more fawn-color. The test of the largest is nearly uniform fawn-color, with the long spines almost white.

Station 3810. Off Honolulu Light, Oahu, 53–211 fathoms.
" 3811. Off Honolulu Light, Oahu, 52–238 fathoms.
" 4045. Off Kawaihae Light, Hawaii, 147–198 fathoms.

Six specimens.

Gymnopatagus obscurus A. Ag. and Clark.

This species differs from the preceding in the conspicuous groove for the anterior ambulacrum, the presence of 6–9 primary tubercles in the posterior interambulacrum, the higher and more ovate test, and fewer tubercles in the lateral interambulacra. The specimens are all of about the same size and measure 85 mm. in length, by 70 mm. in width and 35 mm. in height. The test is widest at about the middle of the posterior pair of petals, which are nearly as long as in the preceding species. The primary spines are only about 20 mm. long. The color is dull brown, the spines somewhat lighter.

Station 3912. Off Diamond Head Light, Oahu, 310–334 fathoms.
" 4081. Off Puniawa Point, Maui, 202–220 fathoms.

Eight specimens.

Lovenia grisea A. Ag. and Clark.

This species is near *L. gregalis* Alcock, but is much more heart-shaped, flatter, and decidedly narrower posteriorly. The test is densely covered with spines, and the lateral ambulacra are quite different from those of *gregalis*. On the actinal surface, the bare posterior ambulacra are not nearly so wide as in de Meijere's (1904) figure of *gregalis*. Unfortunately the single specimen is so badly injured that there is no trace of the abactinal system and internal fasciole; the subanal fasciole is also injured. There is no anterior lateral fasciole. The petals are well-developed, nearly closed and pointed, with the poriferous zones almost straight and scarcely sunken. The specimen is 81 mm. wide and only 26 mm. high; it must have been about 90 mm. in length. The anterior lateral ambulacra are only 4 mm. wide at a distance of 15 mm. from the ambitus, but at the ambitus they are 12 mm. The color is light olive gray.

Station 4080. Off Puniawa Point, Maui, 178–202 fathoms.

Pseudolovenia A. Ag. and Clark.

This genus resembles Lovenia very closely when the specimens are covered with spines, but when the abactinal surface is denuded the difference in the posterior ambulacra is very striking. These ambulacra are not petaloid, the poriferous zones are flush with the surface of the test, and, though slightly converging at first, diverge towards the ambitus, the petals becoming more and more open, while the pores of a pair come closer together until, below the ambitus, there are only single pores. The anterior lateral ambulacra are subpetaloid with the poriferous zones flush. Fascioles, tubercles, and spines much as in Lovenia.

Pseudolovenia hirsuta A. Ag. and Clark.

The test is distinctly heart-shaped with an evident groove for the anterior ambulacrum. It is densely covered, especially in the young, with slender miliary spines 2–4 mm. long. The abactinal system is only about one-third of the length, from the anterior extremity, and is more anterior still in very young individuals. The test is highest at or behind the abactinal system. The number of large primaries increases with size; there are 2 or 3 in each anterior interradius and from 3 to 8 in each lateral interradius, in specimens under 50 mm. in length. In larger specimens there may be as many as 6 in front and 12 on the side. The largest specimen is badly damaged at the posterior extremity, but is 54 mm. wide and must have been nearly 65 mm. long; it is a trifle over 22 mm. high. Smaller specimens are relatively higher and narrower. In the best preserved specimen, which is 60 × 51 mm., the posterior ambulacra from the internal fasciole to the margin measure 33 mm.; the interporiferous area is 3 mm. wide at the fasciole, 2.25 mm. wide 13 mm. from the fasciole, and 5 mm. wide at the ambitus. The color is gray, becoming dirty white in the largest specimen. Young specimens are more nearly cream-color. The primary spines are white, and in the largest specimen are from 30 to 37 mm. long.

Station 3836. Off Lae-o Ka Laau Light, Molokai, 238–255 fathoms.
" 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 3865. Off Mokuhooniki Islet, Pailolo Channel, 256–283 fathoms.
" 3920. Off Diamond Head Light, Oahu, 265–280 fathoms.
" 4028. Off Ukula Point, Kauai, 444–478 fathoms.
" 4036. Off Kawaihae Light, Hawaii, 687–692 fathoms.
" 4083. Off Puniawa Point, Maui, 238–253 fathoms.
" 4122. Off Barber's Point Light, Oahu, 192–352 fathoms.

Eighteen specimens.

BRISSINA Gray.

Rhinobrissus placopetalus A. Ag. and Clark.

The specimens are small and immature, but the shape of the test and the large petals flush with the test distinguish this species from any previously known. The test of the largest is 14 mm. long and 12 mm. wide, lowest anteriorly and sloping steadily upward to the posterior extremity, where it is highest. It is widest at the abactinal system, which is just over the mouth. At this point the vertical height is 8 mm., while at the posterior end it is 10 mm. The anterior ambulacrum is flush, with few very minute pores. The other ambulacra are distinctly petaloid, scarcely sunken, and are subequal, 4 mm. long with 13 or 14 pairs of pores. The peripetalous, anal, and subanal fascioles are all well developed. The color is light yellowish-brown.

Station 4146. Vicinity of Modu Manu, 23–26 fathoms.
" 4160. Vicinity of Modu Manu, 31–39 fathoms.

Three specimens.

Brissopsis luzonica A. Ag.

Kleinia luzonica Gray, 1851. Ann. Mag. Nat. Hist. (2) 1, p. 133.
Brissopsis luzonica A. Agassiz, 1872. Rev. Ech. Pt. 1, p. 95.

A good series of this species is found in the collection, but owing to the fragility of the test (see Döderlein, 1906) most of them are more or less badly broken.

Station 3836. Off Lae-o Ka Laau Light, Molokai, 238–255 fathoms.
" 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 4044. Off Kawaihae Light, Hawaii, 198–233 fathoms.
" 4083. Off Puniawa Point, Maui, 238–253 fathoms.
" 4131. Off Hanamaulu, Kauai, 257–309 fathoms.
" 4132. Off Hanamaulu, Kauai, 257–312 fathoms.

Twenty-four specimens.

Brissopsis Oldhami Alcock.

Brissopsis Oldhami Alcock, 1893. Jour. Asiat. Soc. Bengal, **62**, Pt. 2, No. 4, p. 6 (174).

Our specimens agree exactly with Alcock's description, but as he gives no measurements and his figures are of a small specimen, it is not easy to see why he

did not regard the Indian form as *luzonica*. Comparison of the Hawaiian specimens of *Oldhami* and *luzonica* reveals several apparently constant differences which warrant their separation. In *luzonica*, the breadth of the test is usually .80–.85 of the length, though it may be more; in *Oldhami* it is over .90. In *luzonica* the width of the area enclosed by the peripetalous fasciole is about .50 of its length, rarely more than .55; in *Oldhami* it is .60–.70. In *luzonica* the height of the subanal fasciole is about .50 of its horizontal breadth; in *Oldhami* it is rarely over .40. The actinostome is more deeply sunken and the labrum is more prominent and more nearly pointed in *Oldhami* than in *luzonica*. The petals are slightly broader and the lateral petals are a little longer, and are more noticeably depressed below the fasciole, in *Oldhami*. It is evident therefore that this species is nearer *lyrifera* than *luzonica* is, but it agrees closely with the latter in color and fragility of the test. The largest specimens are about 50 × 45 mm.

Station 3824. Off Lae-o Ka Laau Light, Molokai, 222–498 fathoms.
" 3826. Off Lae-o Ka Laau Light, Molokai, 371–430 fathoms.
" 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
" 3842. Off Lae-o Ka Laau Light, Molokai, 495–506 fathoms.
" 3863. Off Mokuhooniki Islet, Pailolo Channel, 127–154 fathoms.
" 3892. Off Mokapu Islet, Molokai, 328–414 fathoms.
" 3908. Off Diamond Head Light, Oahu, 304–308 fathoms.
" 3912. Off Diamond Head Light, Oahu, 310–334 fathoms.
" 3916. Off Diamond Head Light, Oahu, 299–330 fathoms.
" 3917. Off Diamond Head Light, Oahu, 294–330 fathoms.
" 3918. Off Diamond Head Light, Oahu, 257–294 fathoms.
" 3992. Off Mokuaeae Islet, Kauai, 528 fathoms.
" 3997. Off Ukula Point, Kauai, 418–429 fathoms.
" 4028. Off Ukula Point, Kauai, 444–478 fathoms.
" 4132. Off Hanamaulu, Kauai, 257–312 fathoms.

Thirty-seven specimens.

Brissopsis circosemita A. Ag. and Clark.

We have given this name to a small Spatangoid, of which there is only a single specimen, and that a bare test 17 mm. long, 14 mm. wide, and 11 mm. high. The posterior extremity is truncate vertically. The plastron is slightly keeled posteriorly. The labrum is nearly straight, and the actinostome is scarcely sunken. The peripetalous fasciole and the petals are similar to those of a young *luzonica*, but the subanal fasciole is unique. It is quite small and nearly circular, 5 mm. in transverse diameter and 5.25 mm. vertically. A conspicuous branch arises from the upper portion, on each side of the anal system, and runs to the posterior portion of the peripetalous fasciole, which it joins in the posterior ambulacrum. The two branches thus enclose the anal system, but are not very near to it. While such anal fasciolar branches are not uncommon in Brissopsis, they are particularly distinct and complete in this specimen. Only three ambulacral plates enter the subanal fasciole on each side. The abactinal system is very compact

and the genital opening in the right anterior plate is much smaller than the other three.

Station 4070. Off Puniawa Point, Maui, 45–52 fathoms.

Brissus carinatus Gray.

Spatangus carinatus Lamarck, 1816. Anim. s. Ver. **3**, p. 30.
Brissus carinatus Gray, 1825. Ann. Phil. **10**, p. 9.

There is a bare test, 55 × 42 mm., from Laysan Island, which is undoubtedly this species. We also refer to Brissus, and probably *carinatus*, a young Spatangoid about 10 mm. long, in which the petals are not quite perfect and are little sunken, while the subanal fasciole is disproportionately large. It was taken at Station 4147, vicinity of Modu Manu, in 26 fathoms.

Metalia maculosa A. Ag.

Echinus maculosus Gmelin, 1788. Linn. Sys. Nat., p. 3199.
Metalia maculosa A. Agassiz, 1872. Rev. Ech., Pt. 1, p. 144.

A small fragment of the right posterior ambulacrum and part of the posterior interambulacrum of a large Spatangoid from Station 4149 is evidently from the test of one of this species.

Station 4149. Off Modu Manu, 33–71 fathoms.

Aceste Wyv. Thom.

Aceste Wyville Thomson, 1877. Voy. Chall. Atlantic, **1**, p. 376.

There are a few good specimens, and fragments of several others, of this genus, but none of them seem to be *bellidifera*, the only species hitherto known. They all agree in having the posterior extremity nearly vertical and the anterior furrow deep and with nearly vertical sides. The actinal plastron is perfectly flat and does not project either in front of or below the mouth. In these particulars the specimens are evidently different from *bellidifera*, and the difference is emphasized when the relative length of the plastron is noted. In *bellidifera* the plastron measures from the posterior edge of the tuberculated portion to the mouth, only about .65 of the length of the test, while in the Hawaiian specimens it is considerably more than .75. Not only do these specimens differ from *bellidifera*, but those from the west end of Molokai are obviously different from those taken off the west coast of Hawaii, and we are accordingly obliged to recognize two new species of *Aceste*.

Aceste ovata A. Ag. and Clark.

The points in which this species differs from *bellidifera* have already been stated. The largest specimen is 19 × 15 mm. and the others are nearly as large. The test is broadly ovate, rounded behind. It slopes backward slightly from the posterior edge of the fasciole for a very short distance, and is then vertically truncated. The fasciole is nearly oval and not angular, though it is somewhat pointed behind. The color of these specimens is light brown, with the fasciole a somewhat darker brown.

Station 3836. Off Lae-o Ka Laau Light, Molokai, 238–255 fathoms.
" 3839. Off Lae-o Ka Laau Light, Molokai, 259–266 fathoms.
Six specimens.

Aceste purpurea A. Ag. and Clark.

This species differs from the preceding in the shape of the fasciole and in color. The fasciole is somewhat angular, though the angles are rounded, and the enclosed area is abruptly widened just behind the middle of its course. The general color is pale purple, with the fasciole a very deep purple. A small specimen, only 13 mm. long, from St. 3898, has this same coloration, and, although the fasciole has no prominent angles, is evidently this species. The largest specimen is nearly 22 mm. long.
Station 3898. Off Mokuhooniki Islet, Pailolo Channel, 258–284 fathoms.
" 4041. Off Kawaihae Light, Hawaii, 253–382 fathoms.
Three specimens.

Schizaster japonicus A. Ag.

Schizaster japonicus A. Agassiz, 1879. Proc. Amer. Acad., **14**, p. 212.

A very small Spatangoid, only a trifle over 8 mm. in length, is evidently a Schizaster, and in the appearance of the petals is more like *japonica* than it is like any other described species.
Station 4064. Off Kauhola Light, Hawaii, 63–107 fathoms.

Periaster maximus A. Ag. and Clark.

Although there is in the collection only a single fragment of this Spatangoid, it shows such great size for a Periaster and such unique features, we feel justified in giving it a name. The fragment is the posterior left-hand quarter, approximately, of the abactinal part of the test and includes the left posterior petal and most of the right one too. The anal system is also present, but no part of the test below it. A perfectly bare band, two millimeters wide, runs from the posterior part of the peripetalous fasciole, in the median line, straight to the anal system. This band is nearly 50 mm. long. The petals are 18 mm. long by 6 mm. wide. The anal system is 11 mm. across horizontally. The shape of this species was apparently more like *limicola* than like *tenuis*, and if we calculate its dimensions by proportion, comparing it with a specimen of *limicola* 65 mm. long, we find that, unless the shape was very different from that species, this individual must have been about 110 mm. long, 105 mm. wide, and 95 mm. high. The color is very light brown. There are some large primary tubercles in the interambulacra, within the fasciole.
Station 4130. Off Hanamaulu, Kauai, 283–309 fathoms.

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A COLLECTION OF SPHECIDAE FROM ARGENTINE.

By H. T. Fernald.

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No. 9. — *A Collection of Sphecidae from Argentine.*

By H. T. Fernald.

The Sphecidae here reported upon form a part of a general collection of several orders of insects made by Prof. W. M. Davis of Harvard University during the years 1871 to 1873, while a member of the staff at the Astronomical Observatory at Cordova, Argentine. Professor Davis, although much occupied by his regular duties, was interested in the fauna and flora of the region where the Observatory was located, and devoted considerable time to making collections and observations on the insects found there, and the specimens, together with remarkably fine records of his observations, are now at the Museum of Comparative Zoölogy.

The Sphecidae in the collection are represented by seventy-seven specimens, and include several forms apparently hitherto unknown to science. An opportunity to study these specimens has been obtained through the kindness of the Museum authorities. To Professor Davis I am greatly indebted for assistance received during the preparation of this paper.

Pelopaeus figulus Dahlb.

Two female, ten male specimens. Length, 15–22 mm.

Chlorion (Chlorion) cyaniventris (Guer.).

Seven female, five male specimens. Length, 16–24 mm.

Chlorion (Chlorion) hemiprasinum (Sichel).

One female, four male specimens. Length, 19–25 mm.

These specimens differ somewhat as regards color distribution from any of the varieties mentioned by Kohl. The head, thorax, median segment, petiole, coxae, trochanters, and more or less of the femora are blue with a greenish reflection, so strong in some places that the color there might be stated as green with a bluish reflection. The antennae are black except near their tips, the last three or four segments being partly red. The entire abdomen beyond the petiole, the outer

ends of the femora, and the tibiae are red: the tarsi are dark brown with here and there a reddish tinge. Wings uniformly deep fuliginous, with a bluish, or at some angles a greenish, reflection.

This form seems to come nearest to Kohl's variety *nobilitatum*.

Chlorion (Prionony x) striatum (Smith).

Eight female specimens. Length, 18–26 mm.

Chlorion (Prionony x) thomae (Fab.).

Three female specimens.

Chlorion (Prionony x) simillimum, sp. nov.

? *Sphex neoxenus* Kohl, ♀, Ann. natur. Hofmus. Wien, 1890, **5**, p. 363.

? *Sphex ommissus* Kohl, ♂, Ann. natur. Hofmus. Wien, 1890, **5**, p. 364.

Female. Black, without pubescence. Wings uniformly fuliginous, with a greenish reflection as far as the outer ends of the cells, the outer margins with less reflection, and this rather violet than green.

Head quite large, quadrate when viewed from above. Central portion of the clypeus strongly swollen; the anterior margin somewhat reflexed and with a pronounced central notch in a slight depression; its surface glistening, not closely punctured, and bearing black hairs of medium size. Frons considerably excavated near and above the antennal insertions, rather more closely and finely punctured than the clypeus, and with traces of transverse striations along the sides of the well-marked frontal suture from the antennae about halfway to the median ocellus. Ocellar area enclosed by three impressed lines, the posterior line arched backward and crossed by the frontal suture, which is present between and behind the ocelli. The lateral impressed lines extend behind the ocelli a short distance and end just in front of, and lateral to, a small macrochaeta on either side. Distance between the lateral ocelli less than between the ocelli and the eyes; median ocellus much larger than the lateral ones. Upper part of the frons and the vertex minutely, not closely, punctured. Cheeks above more than half the width of the eye, but narrowing quickly downward; with scattered punctures and hairs, the latter larger and longer below. Inner margins of the eyes parallel. Antennae black, the scape with a ferruginous tinge below; the filament somewhat grayish sericeous: first filament segment nearly two-thirds as long as the second and third together. Mandibles long, stout, black, tinged with ferruginous at the tip and along the middle of the lower (outer) margin; with numerous aciculations and black hairs.

Thorax black. Collar rising quite abruptly from the neck, its dorsal edge quite broad from front to rear, rounded, and also evenly rounded from side to side for some distance, then quickly bending downward, the sides bearing faint striations. Surface of the anterior face and dorsal edge of the collar somewhat glistening, sparsely punctured. Sides of the neck and collar, and the upper part of the prothoracic lobe, obliquely striate except a small tubercle anterior to the upper part of the prothoracic lobe, which is smooth and glistening. The prothorax below the lateral sutures is coarsely punctured, and near the coxae has a few faint transverse striations. Margin of the prothoracic lobe fringed with short brown hairs.

Mesonotum rising but little above the top of the collar, with a pronounced median depression nearly reaching the posterior edge of the plate, which is strongly transversely striate, the striations being slightly oblique in front and markedly so near the middle line behind. Scattered punctures are also present. Scutellum considerably higher in the middle than the mesonotum, with a median depression forming a pair of quite smooth, glistening projections, which are quite noticeable and almost large enough to be described as bituberculate. Sides of the scutellum striate and closely punctured. Postscutellum narrow, with no median depression, closely punctured. Dorsum of median segment long, with a faint median depression and its lateral lines depressed; its surface closely, transversely striate, and bearing numerous quite long, black hairs. Posterior end and sides similarly striate and with similar hairs, the striations extending down across the metapleura. Mesopleura and mesosternum coarsely and closely punctured except in front of the coxae. Petiole short, rather stout, almost straight, two-thirds as long as the hind metatarsus, equal to the second hind tarsal segment in length, with small, scattered punctures.

Abdomen black but with a faint ferruginous tinge, rising high and almost perpendicular from the petiole, smooth and glistening. Stigma of the second abdominal plate close to the anterior margin. Dorsal plate minutely, sparsely punctured, some of the punctures forming a row on each side of the middle line, nearly parallel to and a little distance in front of, the posterior margins of the plates. A similar arrangement of the punctures occurs below, except that there they form a narrow band instead of a row. Last dorsal and ventral plates with scattered, coarser punctures, and a few black hairs.

Wings uniformly fuliginous, with a slight greenish reflection except outside the cells, where it is very faint or absent. First and second transverse cubital veins of the fore wing each with a bulla near the cubital. Radial cell rather short, its end rounded. Cubital vein almost obsolete beyond the third cubital cell. A bulla is present in the transverse cubital vein of the hind wing. Tegulae black, glistening, with a few scattered punctures.

Legs black, very faintly tinged with ferruginous, the tarsi and the middle and hind tibiae somewhat grayish sericeous. Fore metatarsus with eight comb teeth, the first shorter than the others. Posterior face of hind tibiae coarsely brown sericeous. Claws with three teeth evident and one (the inner) microscopic. Tips of the claws ferruginous.

The male differs as follows: — Clypeus and frons with traces of silvery pubescence. Clypeus elongated, its anterior margin slightly, broadly excavated, not reflexed. Inner margins of eyes very slightly approaching downward. Frontal suture not developed in the ocellar area. First and second segments of the antennal filament short, together a very little longer than the third. Distance between the lateral ocelli about equal to that between them and the eyes. Cheeks retaining their greatest width well down before narrowing. Mandibles with less of the ferruginous tinge.

Dorsal edge of the collar and sides of the mesonotum with faint traces of short silvery hairs suggesting pubescence there in fresh specimens. Scutellar projections less marked than in the female. Sixth ventral abdominal plate rather narrowly, deeply excised behind, and covered with short brownish hairs. Claws with four teeth, the inner one, though smaller than the others, being perceptible in favorable specimens.

Length. — Female, 19 mm.; males, 14–15 mm.

Described from one female and two males captured at Cordova, Argentine.

The female comes very close to *neoxenum* Kohl, differing from it, according to the description, in that the abdomen is not red but black with a reddish tinge, the face is not pubescent, the mesonotum is not glistening but striate, the reflection of the wings is not violet or steel blue but greenish, and the length is three millimeters greater than in Kohl's specimen. Remembering, however, what great color variations are present in this group, the difference in the mesonotum seems to be the only one of importance.

The sole specimen of *neoxenum* bore the locality record Vancouver Island, but Kohl is of the opinion that this is an error and that it came from Chili. I have seen large collections of Sphecidae from the northwestern Pacific Coast, but have met with nothing like *neoxenum;* and as the specimen before me from Argentine so closely resembles Kohl's species, I am also of the opinion that *neoxenum* is a South American insect, and that with a longer series for study *simillimum* may prove to be only a color subspecies.

The males agree quite closely with *ommissum* Kohl, except in the color of the abdomen and in the presence of an excised margin on the sixth ventral abdominal plate. I feel confident that they are the same species as the female here described, and that they are likely to prove to be *ommissum*.

If all these assumptions should prove correct, the species will be known as *Chlorion* (*Prionony x*) *neoxenum* (Kohl).

Chlorion (Pseudosphex) pumilo (Tasch.).

Sphex (*Pseudosphex*) *dolichoderus* Kohl, Ann. natur. Hofmus. Wien, 1890, **5**, p. 370.

One female specimen. Length, 12 mm.

Kohl states that *dolichoderus* is very similar to *pumilo*, but separates them on the ground that the latter has three cubital cells, the first receiving the first recurrent, and the second the second recurrent, while in *dolichoderus* the first transverse cubital vein has disappeared so that both recurrent veins join the elongated first cubital cell. In *pumilo* the petiole is nearly as long as the hind metatarsus, while in *dolichoderus* it is only two-thirds the length of this segment. In the former it is as long as the first, second, and half of the third segments of the antennal filament taken together, while in the latter it is scarcely equal to that of the first and second.

In the specimen before me the venation of the right fore wing is that of *pumilo*, while that of the left is that of *dolichoderus*, except that there is a partial first transverse cubital vein extending backward a short distance from the radial cell before it disappears. The length of the petiole is four-fifths that of the hind metatarsus, thus placing this specimen as an intermediate between the two species under consideration, in that regard; and as only the first segment of the filament is present in each antenna, the third distinction cannot be tested.

Kohl's *dolichoderus* came from Chili; Taschenberg's *pumilo* came from Mendoza, close to the Andes on their eastern side; while the specimen now under consideration was taken less than three hundred miles farther east and but a little farther north.

From these facts it seems certain that the distinctions between *dolichoderus* and *pumilo* represent individual variations merely, and that the former must be considered a synonym of *pumilo*.

Chlorion (Proterosphex) argentinum (Tasch.).

Two female specimens. Length, 22–24 mm.

These specimens hardly agree with the descriptions of this species in all regards. The differences are mainly those of color distribution, however, and it is doubtful if they are of great importance.

The enlarged portion of the first dorsal abdominal plate is black except a narrow posterior and lateral strip of red. On each side of the second dorsal plate is a half-moon shaped black spot, its curved side being posterior. The fourth dorsal plate is black except for a narrow red posterior margin which on the middle line extends into the black in the form of a V. All the other parts of the dorsal plates are red. The surface beneath is red except for two black, rather vaguely limited black bands on the first ventral plate which extend outward and backward from the petiole.

In his key leading to this species Kohl describes the tibiae as suddenly thickened at the end on the inner side. This is somewhat misleading, as, though the end is thickened, it is not suddenly so, his Figure 18 being a better representation than his Figure 20.

Chlorion (Proterosphex) davisi, sp. nov.

Female. Black; wings hyaline except at tip and near base; large, robust.

Head large, not quadrate from above, the frons being depressed between the eyes and the cheeks sloping sharply toward the neck. Clypeus and frons densely covered with pale yellow pubescence and long hairs of the same color. Clypeus somewhat arched, its anterior margin evenly rounded except for a small truncated central lobe. Frons quite deeply sunken between the eyes, pubescent nearly to the ocelli, and where bare, showing scattered punctures of medium size. Ocellar area rather faintly limited by depressed lines, the frontal suture evident from the pubescence to the anterior ocellus. Vertex narrow from front to rear, bearing scattered, long brown hairs. Distance between the lateral ocelli slightly greater than between them and the eyes. Cheeks about half the width of the eye, widest opposite the middle of the neck and narrowing quickly above and below, glistening, with scattered punctures, thicker below, where there are also numerous long dark brown hairs. Inner margins of the eyes about parallel. Antennae black, grayish or brownish sericeous beyond the first filament segment, the scape tinged with ferruginous beneath, with a trace of yellowish pubescence at the base and short dark brown hairs on the inner side and tip. Mandibles quite stout, black, with a faint

ferruginous tinge; with a row of aciculations on the outer edge and bearing an irregular fringe of quite long black hairs. Terminal tooth of each mandible extending some distance beyond the base of the other.

Thorax. Neck short. Anterior face of collar very flat, rising at right angles to the neck, its surface sparsely pale yellow pubescent. Dorsal edge of collar very narrow, evenly rounded, closely appressed against the mesonotum. Sides of the collar glistening in front of the prothoracic lobe, and excavated, forming quite a sharp vertical ridge anteriorly. Prothoracic lobe with a few scattered punctures and brown hairs, and with a trace of golden pubescence behind. Prosternum sparsely punctured, bearing quite long brown hairs. Mesonotum rising somewhat sharply at first above the collar, with a faint, short, anterior median depression; its surface evenly but not closely covered with punctures of medium size, pale sericeous at certain angles, and bearing a few short brown hairs; its lateral margin somewhat reflexed from in front of the tegulae to the posterior corners. Scutellum rather broad from front to rear, and quite flat, its surface somewhat glistening, and punctured about like the mesonotum, with a slight median depression behind. Postscutellum narrow, strongly bituberculate, minutely punctured. Dorsum of the median segment closely, transversely striate, the striations being coarser at the sides behind the stigma, but not extending beyond the limits of the dorsum; its surface quite thickly covered with rather short, erect, brown hairs. Fovea broadly crescentic. Posterior end of the median segment forming nearly a right angle with the dorsum; its surface granular, and bearing quite a thick clothing of long brown hairs. Toward the sides there are faint traces of striations above, but the surface for some little distance behind the stigmatal groove is smooth except for minute punctures, and somewhat glistening. Stigmatal groove running forward some distance from the hind coxae, then turning sharply upward to the stigma close behind a pronounced, narrow, vertical ridge, which extends down from the front of the stigma to a point a little below the bend of the stigmatal groove. Meso- and meta-pleura rather closely and minutely punctured, quite thickly covered with short brown hairs. Petiole black, with a faint reddish tinge, short, straight, a little shorter than the second hind tarsal segment, or the first filament segment, one-third longer than the second filament segment; its surface minutely punctured, and bearing short brown hairs.

Abdomen quite long in proportion to its width, rather pointed behind, black with a dull reddish tinge, particularly on the sides and beneath, whitish or grayish sericeous, particularly on the second and third dorsal plates. Stigmata reddish. Dorsal plates with minute scattered punctures, except the last two, which are quite coarsely punctured and bear a few reddish brown hairs. Beneath, with a number of quite long brown or reddish brown hairs on the last plate.

Wings hyaline, except on the outer margin of the fore wing from the end of the radial cell back to the end of the subdiscoidal vein, and at the base, all of the costal cell and the greater portion of the median, submedian, and anal cells, which are deep brown. The base of the hind wing is similarly colored. Cubital vein obsolete beyond the third cubital cell in the fore wing. That of the hind wing present for a short distance beyond the transverse cubital vein. Radial vein of the hind wing arched strongly forward beyond the transverse cubital. Transverse median vein nearly straight, joining the median at more than a right angle. Tegulae black, with a reddish tinge behind, with a trace of sericeous at some angles.

Legs dark reddish brown to black. Fore metatarsi with eleven comb teeth more than half the length of the segment, the first one shorter. Inner contour of hind tibia straight. Otherwise the legs have no differential characters.

Length, 29 mm. Expanse of wings, 44 mm.

Described from one female specimen captured at Cordova, Argentine.

This species in some regards seems to resemble *Chlorion fuliginosum*, *C. servillei*, and *C. nitidiventris*, but comparison with specimens of the first two species shows numerous differences, and the description of the third fails to agree with it in a number of points.

I take great pleasure in naming this species for Prof. W. M. Davis of Harvard University.

Sphex nigrocinctus, sp. nov.

Female. Head almost all black; thorax, median segment, first segment of petiole, coxae, and trochanters entirely black. The other segments of the legs, and the abdomen, except the fourth segment, red. Wings hyaline, with a faint yellowish shade near the base; slightly fuliginous along the outer margin.

Head large, quite quadrate from above, the cheeks being quite broad at the top and the frons but little hollowed between the eyes. From in front the outline is nearly circular. Clypeus and frons rather sparsely golden pubescent almost to the ocelli and with quite numerous long yellow hairs. Anterior margin of the clypeus with its middle third straight, transverse, and with a small tooth at each end of this portion where the margin bends upward, just above which is a small, noticeable red spot. Centre of the clypeus somewhat arched; but a rounded triangular area from the highest point of this to the margin is flattened. Frontal suture from the antennae to the anterior ocellus well developed, and this region is without pubescence. Ocellar area well marked by depressed lines. Immediately behind it is an elevated transverse-oval area a little wider than the ocellar area. The portions of the frons, vertex, and occiput not pubescent are black sericeous, which on the cheeks close behind the eyes, and covering the whole of the cheeks lower down, becomes golden sericeous. Cheeks wide above, narrowing quickly below the level of the neck, and giving a long wedge-shaped piece, when viewed from the side, the surface above bearing a few scattered, long yellow hairs. Lateral ocelli nearer each other than to the eyes. Inner margins of the eyes parallel. Antennae black, black sericeous, the scape reddish beneath except at its tip, glistening, and with a very few short black hairs. Relative lengths of filament segments 1/31, 2/19, 3/20, 4/19. Mandibles stout, each reaching but little beyond the base of the other, the terminal tooth and inner margin black as far toward the base as the inner side of a well-developed lateral tooth; the remainder red, with scattered aciculations and a fringe of quite long red hairs on the posterior face.

Thorax black; the dorsal edge of the collar, mesonotum, scutellum, postscutellum, middle of the dorsum of the median segment, front of the tegulae, prothoracic lobes, a large triangular area extending backward from the lower part of the episternal groove of the mesopleuron toward the mesocoxae, a large spot on each side of the petiole on the end of the median segment, and a strip along the side of

the dorsum of the median segment from the last to the postscutellum, golden to yellow sericeous or pubescent. In the specimen at hand the prothoracic lobe, the mesopleural triangular area, and the two spots on the end of the median segment are densely pubescent; the others are coarsely sericeous only; but as this specimen shows traces of having been wet, some of the sericeous areas were probably once pubescent. Anterior face of the collar rising perpendicularly from the neck, slightly rounded from side to side; its dorsal edge rather broad and rounded in both directions; the surface of the collar black sericeous where not yellow. Sides of the collar slightly glistening, with a broad groove running obliquely downward and backward, on the posterior side of which, in front of the prothoracic lobe, are a few striations. Lateral suture of the neck and collar slightly fringed with short yellow hairs. Mesonotum rising considerably above the collar, with a median groove extending back about half the length of the plate. Lateral margins of the mesonotum strongly reflexed to its posterior corners, where this reflexed edge is continued inward by the lateral anterior margin of the scutellum a short distance. It then turns backward, and soon unites with the central part of the scutellum, which is rounded downward anteriorly. Scutellum with a slight median depression posteriorly, on each side of which are a few coarse longitudinal striations. Postscutellum without a median depression, but with coarse striations, as on the scutellum. Dorsum of the median segment with its surface back to the stigmata sericeous or pubescent, which behind this grows narrower till it reaches the posterior end, the sides of the dorsum, which is much broader behind the stigmata, lateral to the sericeous covering, being coarsely striate, the striations being nearly but not quite transverse. Posterior end of the median segment sericeous where not pubescent. Sides of the median segment coarsely rugose, the ridges running nearly vertical posteriorly, and obliquely downward farther forward. Numerous short yellow hairs are present on this surface. Mesopleuron with numerous punctures, coarser below, with yellow hairs. Below the triangular pubescent spot are short, rather irregular ridges running nearly vertical and soon becoming obsolete, below which the surface is sparsely punctured and bears yellow hairs. Metapleuron with striae or rugosities running obliquely forward and downward on the upper part of the plate, vertically downward on the lower part. Near the upper, outer angle of the metacoxa is a pronounced, flattened tubercle.

Abdomen. Petiole of two segments, the first cylindrical, black, somewhat grayish sericeous, the second elongate conical, black near its base above and below, the remainder red, five-sixths as long as the first segment. Remainder of the abdomen entirely red except a band of blackish on the fourth dorsal plate which covers all but the posterior margin and a very small place on the median line anteriorly, and is lighter along the median line. Posterior margin of the seventh dorsal plate oval in outline. Surface of the abdomen grayish sericeous above, somewhat glistening beneath, and here with scattered punctures most abundant on the posterior part of each plate, and more abundant on the seventh. Posterior margins of the third to sixth ventral plates inclusive, rounded, with a central emargination which becomes more of a notch behind. Seventh ventral plate conical, its sides rolled in at the tip so that with the end of the dorsal plate a nearly circular opening is formed; its surface bearing numerous whitish hairs, chiefly at the sides near the end.

Wings, hyaline, the fore wings with a yellowish tinge from the base to the

outer end of the inner cells. Outer margins of both pairs faintly fuliginous beyond the cells. Cubital vein of the fore wing entirely obsolete beyond the third cubital cell except for a very short stub. Subdiscoidal vein also with a short stub beyond the second recurrent, but with a dark streak extending a short distance beyond. Radial vein of the hind wing with a short stub and darker streak beyond the transverse cubital. Cubital not extending beyond the transverse cubital. Veins brown, the subcostal and anal of the fore wing, and the anal of the hind wing, almost black. Tegulae dark brown, lighter behind, golden sericeous, almost pubescent except near the hinder margin.

Legs. Coxae and trochanters black. Fore coxae and trochanters slightly yellow sericeous, the former with scattered yellow hairs. The other segment of the fore legs red, more or less sericeous, the last two tarsal segments darker than the others. Claws dark brown. Middle and hind legs like the fore legs except for a slight dark streak on the posterior side of the hind femora. Spines on all the legs red. Fore metatarsus with eight comb teeth on the outer margin.

Length, 31 mm. Expanse of wings, 40 mm.

Described from one female specimen taken at Cordova, Argentine.

This striking species closely resembles *eugenia* Smith, but differs from it in the outline of the clypeus, the sculpturing of the dorsum of the median segment, and in the distribution of color on the abdomen and legs. If this insect is subject to much variation, it may prove to be Smith's species.

Sphex fragilis (Smith).

Twenty-three female, sixteen male specimens. Length: females, 15–23 mm.; males, 13–20 mm.

"Common on the altos about the last of October on the yellow flowers of a Cladrastis (Chanar)." Davis.

This interesting series shows much variation in size and in the amount of red present on the abdomen, but every gradation between the extremes is present, and I am unable to make more than one species of the lot. Most of the specimens come nearer *suavis* Burm. than to *fragilis*, but as the difference between the two as given by Burmeister consists only in a larger amount of red in *suavis*, it would seem to be simply a color variation.

In all the specimens, at least the median dorsal surface of the last three abdominal segments is black. In many the black areas are broader, covering more of the surface of these plates; in others the black begins to affect the posterior ventral plates and extends farther forward above, and this extension of the black proceeds till in some specimens only the second segment of the petiole, the segment next behind this, and the anterior margin of the next, are red, and the base of the second petiole segment is black or dark above. As the black increases in amount it becomes more bluish in quality, as is called for by the description of *fragilis*. None of the specimens show any tendency toward the appearance of *moneta* Smith, as mentioned by Fox (Proc. Acad. Nat. Sci. Phila., 1897, p. 374).

Considerable study of the South American species of this genus leads to the belief that variation in the amount and distribution of color has resulted in the description of a number of species which will not prove valid when large numbers of specimens can be brought together for study, but a careful examination of the types in various European museums should precede any work of this kind if trustworthy results are to be expected.

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